



Radiation Physics Note 69

Summary of the Accelerator Division Test Reports on Various Aspects of Uranium

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March 23, 1988

Introduction

Several areas of concern have been identified as we approach the production stage of uranium modules for the DØ calorimeter. It has been determined that the uranium plates need to be cleaned to remove rolled in hairs, lint, oils and other sources of contamination to the detector electronics and detector argon. It was discovered that significant quantities of uranium oxides have developed in completed modules and that current leakage problems may be associated with this oxide formation.

The purpose of this note is to bring together those tests which have been performed to find methods to clean and to prevent accelerated corrosion of uranium. This note is not all inclusive; other tests are currently being performed or evaluated to answer other questions.

These tests have been conceived and performed by persons from the DØ and the AD Safety Groups.

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December 30, 1987

SUBJECT: 12/21/87 Sanding Test on Depleted Uranium

REFERENCE: Memo entitled "Test to Check the Safety and Effectiveness of Uranium Plate Cleaning with a Portable Vibrating Sander" and dated 11/24/87

The following items correspond to numbered items in the referenced memo. For completeness, see the referenced memo.

1. The sander was tested on rusty steel plates on four different occasions using different dust skirt configurations including no skirt. The sander had been modified to eliminate unwanted discharges of oxides into the air and to improve the dust collection skirt design so that it would be structurally strong enough to withstand vibration from the sander. The tests gave us some confidence that the sander might work without causing high levels of UO_2 to become airborne. (See Attachment I for test results.)
2. Personal air monitors (PAMs) were worn by the sander operator, the Rad Tech, and myself. The flow rate of the PAM, the short duration of the sander in operation (~ 5 minutes), and counting statistics limit the sensitivity of the air sample. The results of all monitors were $<3.08 \text{ E-11 uCi/ml}$, that is, less than 31% of the limit for uranium dust in air.
3. Half face respirators were worn by all persons in the room. The North respirators (HEPA) were used and were most uncomfortable, possibly due to the lack of familiarity with how tight the fit must be. For future use, it is recommended that an indicator be used to test the fit with less tension and vary tension as necessary for both comfort and a good seal.
4. A PAM was placed about 1 foot above the table to check for UO_2 concentrations. The average concentration for the duration of the test was $<2.99 \text{ E-11 uCi/ml}$.

5. Earplugs were not worn during this test. The sander was run for a total of about 5 minutes, well under the 2 hour permitted exposure time.
6. Protective clothing was worn as prescribed. The sander operator and Rad Tech were careful to not come in contact with dusty plate surfaces and the clothing appeared to stay clean throughout the test.
7. The work table was set up and isolated as prescribed. The area was rather easy to survey as a result.
8. Traffic control in the room to prevent the spread of contamination amounted to keeping the sander operator and Rad Tech in the designated area. Materials were passed into and out of the area. Vacuum hoses and sander power cords were suspended from a convenient place (crane hook) to keep those items from spreading contamination within the area. Extension cords on the floor were covered with tape (secured to the floor) to prevent their movement. Shoe covers and glove changes were made when persons exited the designated sanding area.
9. Both sides of one IFH plate was sanded (approximately 28 ft²). The plate was carefully turned over by hand (277 lbs) after it was vacuumed and wiped with alcohol. No obvious dust movement occurred, probably due to the precautions taken.
10. The sander was wrapped up and stored as radioactive material upon completion of the test.
11. The work area was surveyed upon completion of the test to determine how UO₂ migrated away from the table. Table surface contamination levels were 0.9 nCi/100 cm². Floor contamination levels at the table perimeter were 0.1 nCi/100 cm². Floor contamination levels several feet away from the sanding table were 0.08 nCi/100 cm².
12. The uranium plate and table surfaces were covered upon completion of the test. Cleanup of other areas was not required.
13. No decontamination was required.
14. Ethyl alcohol and Kimwipes were used to clean the plate after the sanding was performed. Alcohol was not used in conjunction with the sander.

15. No samples were collected for particle size analysis due to manpower limitations. These samples should be collected during subsequent tests.

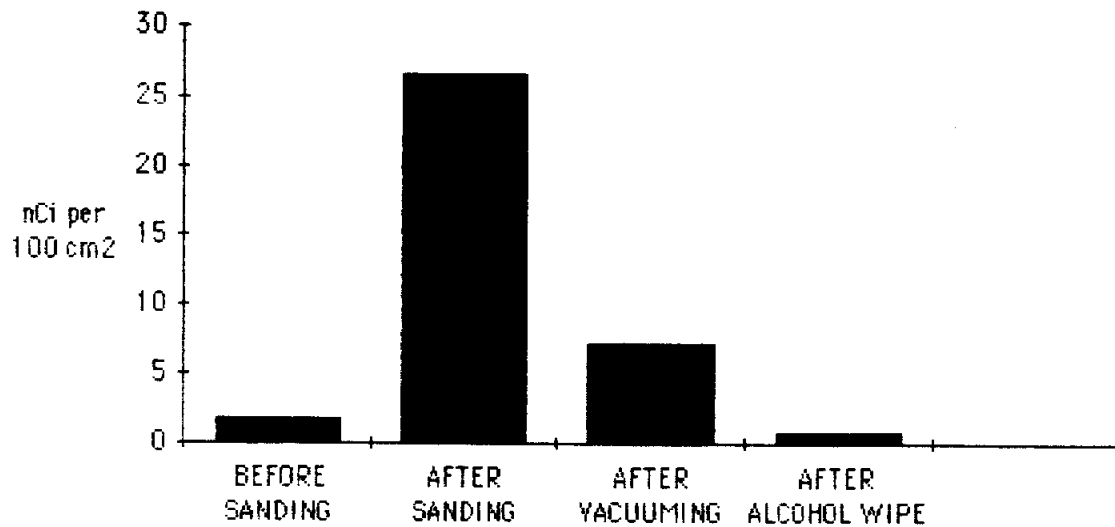
Other Observations

1. The sander appeared to be much more effective when the emery paper was new. The first area sanded quickly turned brown in color indicating that almost all oxides were removed in that area (approximately 2 ft²). Contamination levels were significantly higher in this area compared to other areas of the surfaces sanded.

Subsequently, the sander left the plate color black except for high spots which were shiny. The second side had far less oxides removed as evidenced by the contamination levels found (See Attachment II).

2. The vacuum step reduced contamination levels by about 73% averaged over the two surfaces. It is felt that the levels remaining after the vacuum step are too high to be left because the levels are too high to easily control and present a significant surface contamination problem. (See Graph 1 below.)
3. The contamination levels were further reduced with alcohol and Kimwipes by a factor of 88% averaged over the two surfaces. These levels are comparable to those experience with the MFH plates and are manageable given the controls in place at IB4.

AVERAGE CONTAMINATION LEVELS DURING TEST PHASES



Graph 1

4. For future tests, a high volume air sampler should be used at times when dusts are generated in an attempt to get statistically meaningful count rates on sample papers. A filter paper should be selected based on particle sizes derived from earlier particle size determination tests
5. Some means of flipping these heavy uranium plates should be found to eliminate the need for man-handling and the high potential for back injury.

Attachment I

TEST 1

Vacuum attachments on sander skirt and on dust collector discharge. Red iron oxide dust evident on motor cooling exhaust port.

	Measured Iron Oxide*	Equivalent UO ₂ *
Digital dust meter measurement on table	2.87 mg/m ³	6.05 mg/m ³
Digital dust meter measurement on floor	2.30 mg/m ³	4.85 mg/m ³
Breathing Zone Sample - Delmar Miller	<0.12 mg/m ³	<0.25 mg/m ³
Breathing Zone Sample - T. Leveling	<0.12 mg/m ³	<0.25 mg/m ³

Test 2

Impellor of sander removed; motor cooling blower and dust collector disabled. Boot installed over dust collection and motor cooling ports. Holes drilled in sander casing over sanding platen and vacuum connection installed in boot. Motor cooling and dust collection done by medium performance HEPA vacuum cleaner.

	Measured Iron Oxide*	Equivalent UO ₂ *
Digital dust meter measurement on table	0.26 mg/m ³	0.55 mg/m ³
Digital dust meter measurement on floor	0.22 mg/m ³	0.46 mg/m ³
Breathing Zone Sample - J. Cornele	<0.14 mg/m ³	<0.30 mg/m ³

Test 3

No dust collection on sander to check sensitivity of airborne dust measurements.

	Measured Iron Oxide*	Equivalent UO ₂ *
Digital dust meter measurement on table	5.1 mg/m ³	10.75 mg/m ³
Breathing Zone Sample - T. Leveling	0.46 mg/m ³	0.97 mg/m ³
Breathing Zone Sample - Digital Dust	1.6 mg/m ³	3.37 mg/m ³
Breathing Zone Sample - Digital Dust	0.76 mg/m ³	1.6 mg/m ³

Test 4

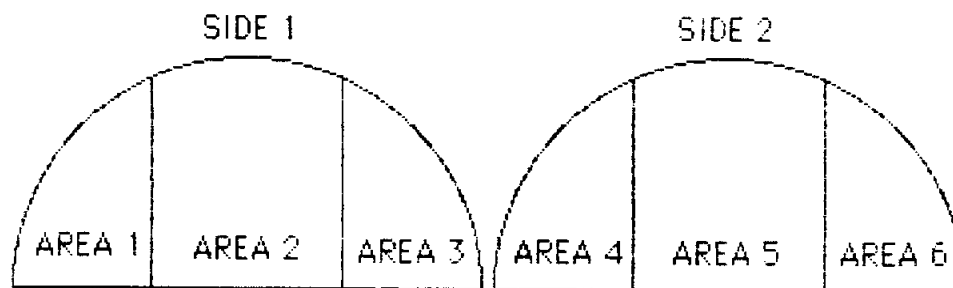
New stainless steel dust collection system installed on sander to replace rubber boot. This was the last prototype tested on rusty steel plate.

	Measured Iron Oxide*	Equivalent UO ₂ *
Digital dust meter measurement on table	0.19 mg/m ³	0.40 mg/m ³
Breathing Zone Sample - J. Cornele	0.031 mg/m ³	0.065 mg/m ³
Breathing Zone Sample - Digital Dust	0.060 mg/m ³	0.130 mg/m ³

*Threshold Limiting Value
12/30/87

Iron Oxide
UO₂
5.0 mg/m³ 0.2 mg/m³

Attachment II



Contamination Levels (nCi/100 cm²)

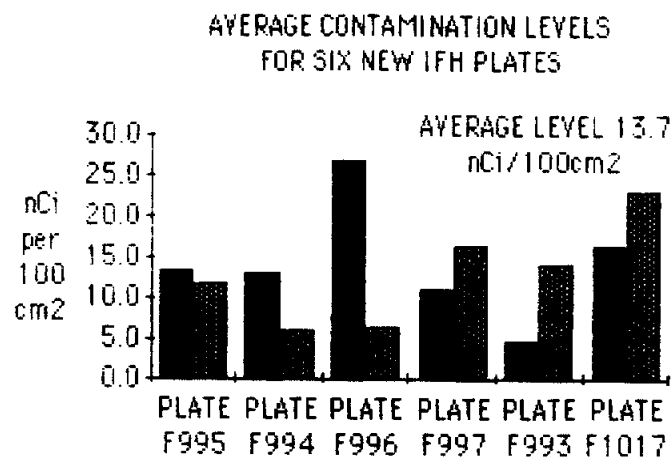
	Area 1	Area 2	Area 3	Area 4	Area 5	Area 6
Before Sanding	1.0	2.5	2.6	1.1	1.2	1.7
After Sanding	67.2	23.7	19.1	22.2	20.2	7.0
After Vacuuming	15.7	6.2	4.8	9.2	4.2	2.9
After Alcohol Wipe	1.2	1.8	0.9	0.4	0.5	0.4

12/30/87

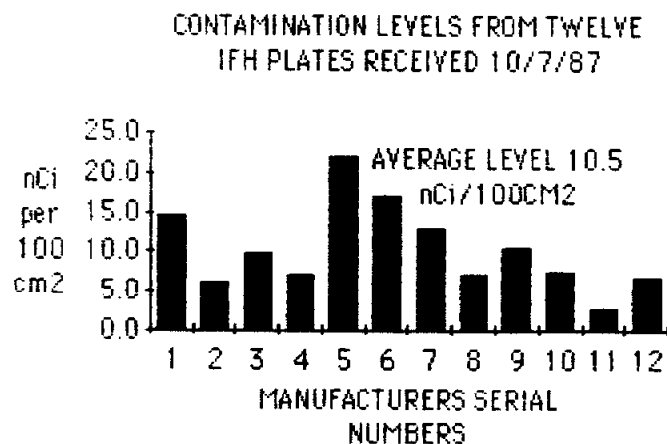
January 18, 1988

SUBJECT: IFH Contamination Level Data for Six New Plates

The chart below shows the results of the contamination level survey taken Thursday, January 15 on the new IFH plates. The dark bar indicates the average of six smears taken on a side and the light bar indicates the same average for the reverse side (total of 72 smears).



The graph below shows the contamination levels found in the first shipment of IFH plates received in October, 1987. Only one smear was taken per plate.



It appears that the contamination levels found in the second shipment may be a little higher (30%) compared to the first shipment.

January 25, 1988

SUBJECT: 1/7/88 Sanding Test on Depleted Uranium

This test was performed to check the effectiveness of an air driven, vibrating sander using various textures of Scotch Brite pads. Smears were taken before sanding, after sanding, after sweeping with a vacuum brush attachment, and after wiping the plate with alcohol.

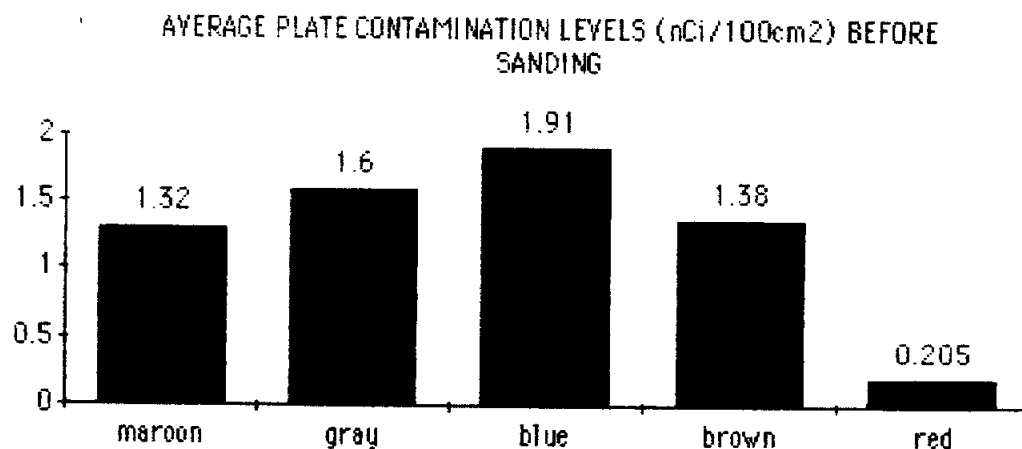
Two uranium plate sides were used to test five different textures of Scotch Brite pad. From least to most aggressive, the pad colors were maroon, gray, blue, brown, and red. The plates (F972-1 and F982-11) had been previously cleaned with using Scotch Brite pads and alcohol. The following are salient points noted during the test.

1. The brown and red Scotch Brite pads used on the Uranium caused sparks to be produced. It is not clear that the sparks were caused by burning bits of elemental uranium, although that is the suspicion. An alternate cause may be that bits of the pad burned as they were thrown off.
2. At one point during the test a Scotch Brite pad was pulled off of the sander and a cloud of dust, probably uranium oxide, was produced. All present during the test were wearing half-face North HEPA respirators and therefore the possibility of a uranium uptake by those present was very unlikely. Based on this observation, it will be important that we require the use of HEPA respirators for future operations of this type.

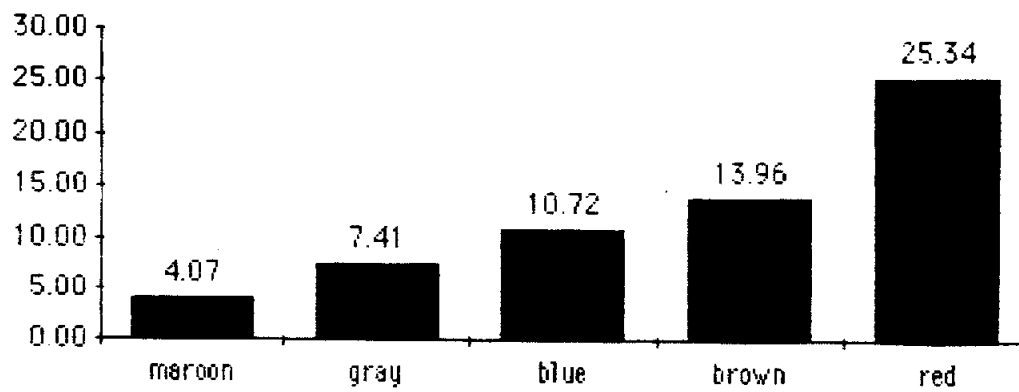
The High Volume Air Sampler was running approximately three feet away from the cloud when this occurred, and we found that this sample did show high levels of airborne activity.

3. The air driven sander rotates at a significant speed (at least 1000 rpm) with no load. The rotation speed drops very significantly as soon as a load is applied.
4. Bits of some of the Scotch Brite pads were thrown off a short distance (less than six inches) as the sander was used on edges of the plate. This was observed to occur when the maroon, gray, and blue pads (the softer pads) were used.

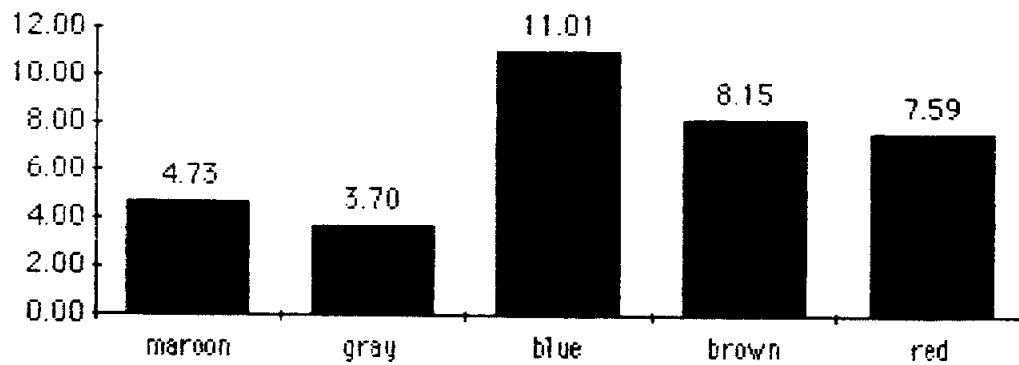
5. At one point during the test when the brown (second most aggressive pad was used) two of those present during the test noticed a fume odor in the respirator which could had been metallic. The source of the odor is not clear but should be watched for in subsequent tests. In any case, the odor was present for less than a minute. The high volume air sampler was running while the odor was present, but particle collection size and efficiency of the paper used may not be sufficient to capture the fume.
6. We attempted to use a glass membrane air sample paper for air sample analysis. The paper has an efficiency of >99% for particle sizes < 0.4 microns. The paper is very flimsy compared to the Whatman 41 paper (poor efficiency for sub-micron particles) normally used, and it collapsed into the sampler almost immediately. For subsequent tests, a fine screen will be installed in the sampler to support the paper and prevent its collapse.
7. The continuous air monitor was used during the performance of the test. No gross air problems occurred during the test as indicated by the strip chart recorder on the instrument.



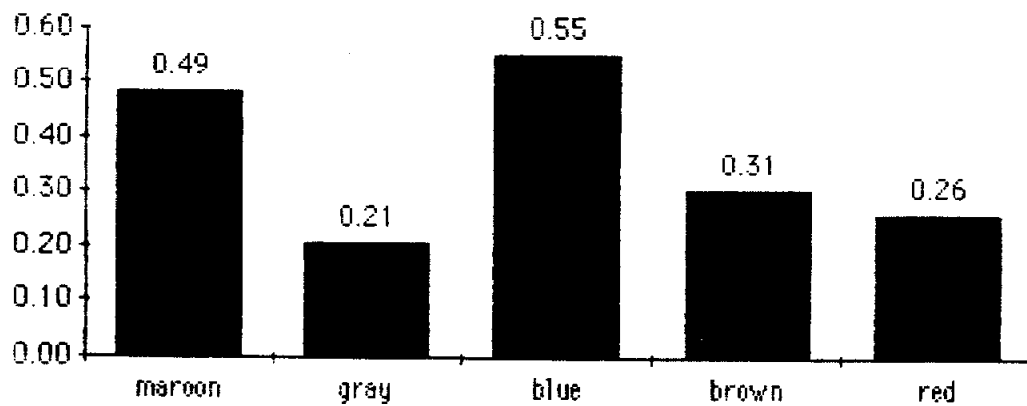
AVERAGE PLATE CONTAMINATION LEVELS AFTER SANDING



AVERAGE PLATE CONTAMINATION LEVELS AFTER VACUUMING



AVERAGE PLATE CONTAMINATION LEVELS AFTER ALCOHOL WIPE



Air Sample Results from 1/7/88
Uranium Sanding Test

Period Sampled: During Gray and Brown Pad Use

High Volume Air Sampler

Started: 1428

Stopped: 1433

Activity: 4.2E-11 uCi/ml

42% of the Maximum Permissible
Concentration

Period Sampled: During Maroon and Blue Pad Use

High Volume Air Sampler

Started: 1352

Stopped: 1357

Activity: 2.0E-11 uCi/ml

20% of the Maximum Permissible
Concentration

Period Sampled: During Red Pad Use

High Volume Air Sampler

Started: 1450

Stopped: 1454

Activity: 3.57E-10 uCi/ml

357% of the Maximum Permissible
Concentration

Period Sampled: Duration of the Test

AMS 3 Continuous Air Sampler

Started: 1020

Stopped: 1043

Restarted: 1312

Stopped: 1525

Activity: 9.0E-12 uCi/ml

9% of the Maximum Permissible
Concentration

Personal Air Monitor Sample Results

Name	Measured	% Maximum Permissible Concentration	Concentration	
Darby*	<6.1E-12 uCi/ml	<6.1%		
Miller			3.0E-11 uCi/ml	30%
Yurista	<6.3E-11 uCi/ml	<63%		
Leveling	<2.2E-12 uCi/ml	<2.2%		

*Result is questionable because air monitor stopped running during the test.

Conclusions

1. Contamination levels are significantly lower compared to manual cleaning. The reason is not clear. A possible cause is that the areas cleaned were relatively small compared with earlier production cleaning experience with MFH and IFH plates. Also, the person doing the cleaning (Delmar Miller) was probably more aggressive during the final alcohol wiping of this relatively small area than workers who did earlier manual cleaning.
2. Significant levels of UO_2 can and do become airborne during sanding operations. At a minimum, the North Half-face HEPA respirators need to be worn by all personnel in the area while uranium plates are sanded. For worker comfort and for additional assurance that no oxide uptakes would occur, we should strongly consider the use of air supplied masks for the performance of this task.
3. This test was of short duration relative to the anticipated production sanding operations. The migratory nature of UO_2 is still not fully understood. During early production sanding operations at IB4 in Area A, a second AMS 3 continuous air monitor should be used to watch for UO_2 migration over the barrier wall around Area A while the current unit monitors areas immediately adjacent to the sanding area.
4. The PAMs are useful in determining potential exposure to airborne oxides. No measureable activity was measured with PAMs prior to this test.
5. The High Volume Air Sampler may give conservative results for measured airborne oxide concentrations because it "hogs" air from the area sampled. In a 5 minute air sample, approximately 100 ft^3 of air is collected. This could represent all or much of the air in the area where sanding is taking place.
6. The use of the air driven, oscillating sander with Scotchbrite pads for cleaning uranium plates is acceptable.
7. The use of Brown and Red Scotchbrite pads should be avoided because of the sparks produced during their use.

January 27, 1987

**SUBJECT: Car Wash Style Uranium Plate Cleaning Test
Results**

The test was performed in an enclosure with dimensions of about 7ft-l X 4ft-w x 4ft-h. The top and small sides panels and the bottom tray were made of aluminum. The two sides through which the spray nozzle was inserted were made of thin plexiglass (~ 1/8"). Several holes were available in each of the plexiglass sides to permit the spray to be inserted into the enclosure so that all areas of the plate could be reached. The holes were covered with duct tape when not in use.

The sprayer developed about 500 psi per the nameplate data on the unit.

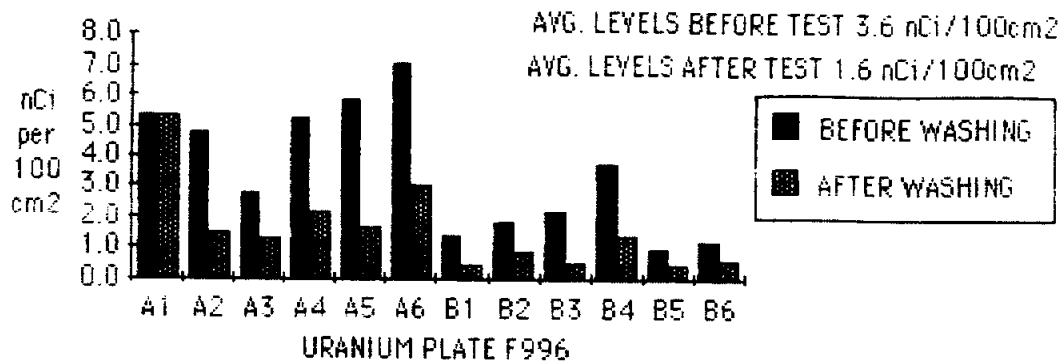
The enclosure was fairly water-tight. Some small water leaks occurred when the spray nozzle was removed from the enclosure. Other leaks occurred when the nozzle was momentarily passed over various joints. No airborne water spray was noticed to come from the enclosure. All leaks consisted of only a few drops of water and were readily picked up with Kimwipes.

The enclosure drained into a filter housing (probably 10 uM filter) which drained into a barrel. The water which came from the filter appeared to be very clear. The water (about 12 gallons) has been retained for analysis and treatment as required.

A visible residue of oxides remained in the enclosure tray. Contamination levels were found to be as high as 13.8 nCi/100cm². The contamination was easily wiped up Masslin cloth.

The test was performed on a single IFH plate. The plate was divided into twelve areas (six per side) and each of the areas were smeared before and after the spray test. The graph below shows the effectiveness of the plate cleaning with the sprayer.

CAR WASH STYLE
URANIUM PLATE CLEANING TEST
JANUARY 21, 1988



A few things to keep in mind regarding this test are:

1. The results of the initial smears are lower than those obtained during the plate arrival survey on January 14. The reason is that the smear/glove that used is not as effective as the glove/smear combination used during the initial survey. For the future, a standard smear/glove combination will be used to ensure that consistent results are obtained.

The test results obtained are considered valid because only one smear technique was used throughout the test.

2. We have no explanation for the before and after contamination levels found for Plate Area A1.
3. Contamination were reduced by 56% over the original levels even when the Plate A1 area is considered. If Plate A1 area is excluded, the levels drop by a factor of 64%.
4. This method of cleaning is more desireable because no uranium oxide dust is created as is the case with sanding. Water spills are easier to find and are also easier to clean up.
5. The sprayer did remove lint fibers which were evident on the edges of the plate before spraying. It is not known whether the wires which are believed to cause shorts when high voltage is applied existed or were removed by this test. Remember that the removal of lint and wires is the primary reason for cleaning

the plates. The contamination level measurements are only used as a method of comparing various cleaning methods.

February 10, 1988

SUBJECT: Water Analysis for Uranium Oxide Contaminated Water

Approximately twenty gallons of water waste containing UO_2 was generated as a result of the car wash style uranium plate cleaning tests performed on January 21st and January 22nd. The water was allowed to stand undisturbed over the weekend (January 23rd and 24th) to permit settling of UO_2 out of solution. On the morning of January 25th, one 250 ml sample was taken on the undisturbed water and a second 250 ml sample was taken after vigorously stirring the water to remix the UO_2 .

An Erlenmeyer vacuum flask, polycarbonate filter papers, and filter chimney were used to analyze the samples. Each of the two 250 ml samples were filtered through 3.0 μm , 1.0 μm , 0.8 μm , and 0.4 μm polycarbonate filter papers. The papers were dried and were subsequently counted on the Tennelec sample counter in the village. The results are given below.

Unstirred Sample

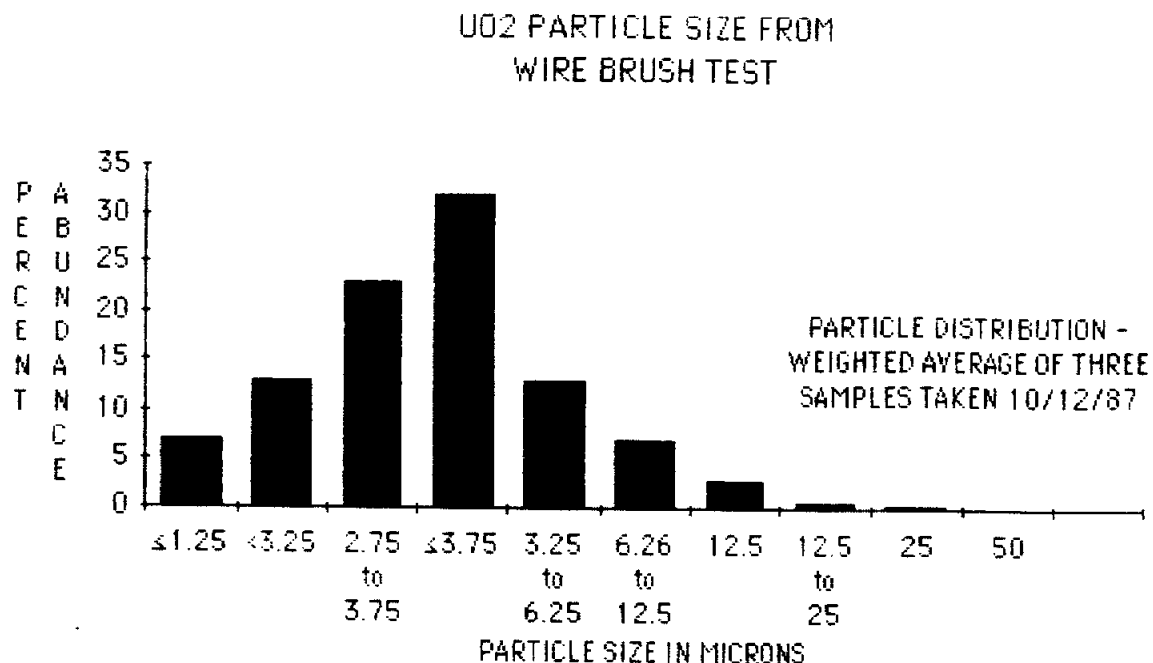
Filter Size (μm)	Activity (nCi)	Specific Activity (pCi/ml)
3.0	0.05	0.2
1.0	0.04	0.16
0.8	0.01	0.04
0.4	<u>0.03</u>	<u>0.12</u>
Totals	0.13	0.52

Stirred Sample

Filter Size (μm)	Activity (nCi)	Specific Activity (pCi/ml)
3.0	1.68	6.72
1.0	0.59	2.36
0.8	0.01	0.04
0.4	<u>0.02</u>	<u>0.08</u>
Totals	2.3	9.20

The range of particles apparent from these samples correspond to those found in the microscopic examination of particles which was done in

October 1987. The result of that microscopic examination is reproduced here for information.



This latest test gives us confidence that only trace quantities of UO₂ exist at < 1.0 μ m.

The discharge limit for water containing uranium oxide is 40 picoCuries per milliliter (pCi/ml). Assuming all oxides are removed by the 0.4 μ m filter, the concentration of UO₂ in the water after filtering with a 1.0 μ m filter would be ~ 0.12 pCi/ml, well below the limit for discharge. Using the same assumption, the concentration of UO₂ in the water before any filtering is 9.2 pCi/ml, also below the discharge limit. Prudence dictates, however, that we at least use the 1.0 μ m filter before these twenty gallons of water are discharged.

Conclusions

1. A 1.0 μ m filter should be used to remove UO₂ to levels desirable for discharge to the sewer system. Sampling as described above and/or sampling by the Safety Section will be performed prior to discharge of this water. Additional filtering and sampling may be required to make levels as low as reasonably achievable (ALARA).

NOTE: The filtered effluent must be stored until an actual analysis proves the water is acceptable for discharge.

2. It is anticipated that a closed-loop system containing a filter will be used in a newly proposed plate cleaning system. There is an indication from the 0.8 μ m and 0.4 μ m filter results that sub-micron particles do exist, albeit in small quantities. These sub-micron particles could build up to relatively high levels after the closed system is used for some time and might eventually need to be filtered in order to reduce levels to ones acceptable for discharge.

THE SAFETY SECTION HAS SINCE STATED THAT NO WATER WASTE WHICH CONTAINED UO2 WILL BE DISCHARGED. ALL WATER WILL BE RETAINED FOR PROCESSING.)

February 17, 1988

**SUBJECT: Sanding/"Car Wash Style" Uranium Plate
Cleaning Test Performed on 1/22/88**

The purpose of this test was to determine the effectiveness of a high pressure spray to clean uranium plates after sanding them with the air driven orbital sander and Scotchbrite pads.

The air driven sander is the one used in tests performed on 1/7/88 and 1/21/88. The enclosure on the water sprayer is the same one used in the 1/21/88 test. See my 1/25/88 and 1/27/88 memos for further details on these subjects.

A major difference between this and the 1/7/88 test is that the plate had to be sanded while standing vertically on its flat edge. The plate was done in this configuration because of the limitations of the spray booth which also served to act as a catch basin under the sanding operation. No visible dust came from the sander.

Various air activity measurements were taken for this test and the results are given below.

Person	Specific activity	% of The Standard
Darby	<1.62 E-10	<162%
Miller	<1.34 E-10	<134%
AMS 3	1.7 E-10	170%
High volume		
Air Sampler	1.33 E-10 uCi/ml	133%

All persons present during the test wore the North HEPA half face respirator. The high "less than" values shown were due to a shorter than desired sample counting time.

The graph below shows the before sanding, after sanding and after washing results. The table shows the values obtained on which the graph is based.

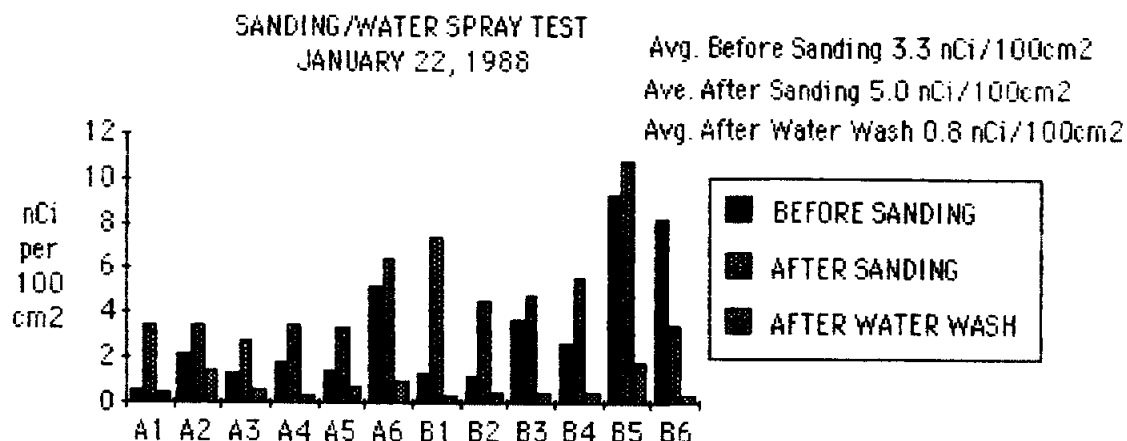


Plate 1017 Contamination Levels - nCi/100 cm²

Area Label	Before Sanding	After Sanding	After Washing
A1	0.7	3.05	0.5
A2	2.2	3.5	1.5
A3	1.4	2.8	0.7
A4	1.6	3.5	0.4
A5	1.5	3.3	0.8
A6	5.3	6.5	1.1
B1	1.4	7.5	0.4
B2	1.3	4.5	0.6
B3	3.7	4.8	0.5
B4	2.7	5.6	0.6
B5	9.3	10.9	1.8
B6	8.3	3.5	0.5
Average Levels	3.3	5.0	0.8

Conclusions

1. Sanding the plates in the vertical orientation leads to high levels of airborne activity and should not be permitted to be performed on a routine basis.
2. The reported "less than" values for Darby and Miller are high due to short counting times (1 minute) used. The Safety Section has subsequently been requested to count all future air samples for 20 minutes. "Less than" values of 40 to 50% of the standard are achievable for personal air monitors when this longer count time is used.
3. The combination of sanding and spraying leads to the lowest contamination levels we have seen yet.
4. The use of warm water for final cleaning is considered to be superior to the use of alcohol and kimwipes for the following reasons:
 - a.) lower final radioactive contamination levels exist on plate surfaces
 - b.) the possibility of introducing lint on plate surfaces by the kimwipes is eliminated
 - 3.) eliminates the fire hazard from extensive use of ethyl alcohol
 - 4.) eliminates exposure of people to ethyl alcohol fumes
 - 5.) volumes of radioactive kimwipe trash produced should be drastically reduced.

March 1, 1988

SUBJECT: Contamination Growth Rate Test on DU and DU-Nb Alloy

The purpose of this test was to compare the growth rate of contamination levels between DU and DU-Nb alloy. The test was done in warm temperatures and high humidity levels to accelerate the corrosion process.

It would be improper to assume that higher contamination levels indicate higher rates of corrosion. It is possible that one of the oxides forms more

readily but adheres more tightly to the parent metal than the the other. It is also possible that the specific activity of the oxides removed from the different coupons is different due to differing concentrations of U²³⁸ daughters in the oxide. Therefore, this test is not intended to show which metal corrodes more rapidly. The test showed which metal presents a greater contamination hazard under the temperature and humidity conditions established for the duration of this test.

Coupons of DU and DU-Nb alloy were obtained from MSC. No documentation was available which confirmed the identity of these coupons. Ten coupons were 1/8" X 2" X 3" and ten were 1/4" X 2" X 3". We believe the 1/8" coupons were DU and the 1/4" coupons were DU-Nb alloy for the following reasons.

1. The BNL modules were built from 1/8" DU plates and FNAL modules were built with 1/4" DU-Nb alloy plates.
2. Nb alloys of DU are harder than unalloyed DU and is more difficult to roll. The 1/8" coupons are smooth and marked only by shallow "pock" marks. The 1/4" coupons, in addition to "pock" marks, has a grainy texture which is some indication that the 1/4" coupons are harder than the 1/8" coupons.
3. The manufacturer made a 1/8" DU-Nb alloy which measured 130 mils in thickness and unalloyed material which measured 118 mils. One DU coupon used in the test was measured and found to be 119 mils which is an indication that the 1/8" coupons are DU.

Test Apparatus

An environmental chamber capable of maintaining a wide range of temperature humidity conditions was obtained. A SS coupon holder rack and an aluminum pan/cover assembly were built for this test. The coupon holder rack containing the coupons was placed on the pan of the pan/cover device. The cover ensured that water which condensed on the cooler surfaces of the chamber bell did not fall on the coupons. This prevented the washing of contaminants into the environmental chamber internals so that the chamber could be returned at the conclusion of the test. The coupons were kept dry and were maintained at the desired temperature/humidity conditions.

Sample Preparation

Two DU and two DU-Nb alloy coupons were scoured with Scotchbrite pads and alcohol to remove oxides from all surfaces except the edges. The effort required to clean the DU (1/8") coupons was much less that that required for

the DU-Nb coupons. This is attributed to some extent to the difference between the surface qualities. Additional scouring was done on the 1/4" plates to ensure that all possible oxides were removed.

The DU coupons were silvery in appearance, similar to the appearance of an old silver quarter (pre-alloy quarter). The DU-Nb coupons were also silvery, but had black streaks due to the grain of the material; i.e., the crevices of the material held some oxides which could not be removed by Scotchbrite pad and alcohol.

After the cleaning step, each coupon was relabeled with a ink marker and the one side of each coupon was labeled A and the other B.

One coupon of each material was also simply wiped with alcohol and Kimwipes.

All coupons were wiped a final time with alcohol and were then smeared. Each smear was taken over both sides of the coupon. Care was taken to ensure the edges (which were not cleaned) were not smeared. The smear results are given below.

Coupon ser. no.	Coupon Type*	Coupon Preparation	Coupon Activity
F998 ¹	DU	Alcohol Wipe	0.22 nCi
F999	DU	Scotchbrite	0.03 nCi
F1000	DU	Scotchbrite	0.05 nCi
F1007 ¹	DU-Nb	Alcohol Wipe	0.97 nCi
F1008	DU-Nb	Scotchbrite	0.22 nCi
F1010	DU-Nb	Scotchbrite	0.22 nCi

¹The history of these coupons relative to one another is not known. Therefore, no explanation for the difference between the contamination levels can be made based on the above data.

*Based on the assumptions stated above

The beginning contamination levels of the two types of scoured samples compare well and are an indication that the test preparation were done in a uniform manner.

Test Performance

The environmental chamber was dried out by running the dry bulb heater with the bell cover removed for several hours. This step ensured that condensation would not immediately form on the cool coupons.

On January 20th, the coupons were then loaded into the chamber and the wet and dry bulb temperatures were set to establish the temperature at approximately 100°F and the relative humidity in the high 90% range. Some fine tuning was done after the chamber stabilized initially. Temperatures and humidities were subsequently recorded on a number of occasions and are shown below.

Date	Dry Bulb	Wet Bulb	Relative Humidity	Date	Dry Bulb	Wet Bulb	Relative Humidity
1/21/88	104°F	103°F	97%	2/4/88	101°F	100°F	97%
1/22/88	102°F	101°F	97%	2/8/88	100°F	96°F	88%
1/25/88	102°F	101°F	97%	2/10/88	101°F	100°F	97%
1/26/88	102°F	101°F	97%	2/15/88	101°F	100°F	97%
1/29/88	102°F	101°F	97%	2/18/88	101°F	100°F	97%
2/1/88	101°F	100°F	97%				
2/2/88	101°F	100°F	97%				

Some inaccuracies in the reported conditions could arise from at least two factors. The thermometers used were the glass-alcohol type and were very difficult to read because condensation was always present on the cool walls of the bell chamber. The accuracy of the thermometers was not checked prior to beginning the test.

First Data Point 1/28/88

Smear samples were taken on January 28. The bell chamber was removed and one side of one DU and one DU-Nb alloy coupon was smeared. The smear was rubbed over the surface twice. The coupons were replaced in the chamber and the dry bulb temperature was set at about 160°F while the wet bulb temperature was reduced to 0°F in an attempt to prevent moisture from condensing on coupons which may have been cooled while the smears were taken. After approximately 15 minutes, the temperature settings were returned to their previous values to reestablish the approximate conditions established earlier in the test.

The the color of the DU coupon was a very solid charcoal black. The color of the DU-Nb alloy looked like a bronze plate with a fairly complete black wash of color; i.e., traces of bronze could still be seen on the coupon.

The smear from the DU coupon was light gray in color. The smear from the DU-Nb alloy was black in color. The smear results are given below.

Coupon	Coupon Color	Smear Color	Activity
F999A	Black	Light Gray	0.34 nCi
F1010A	Bronze with Black Wash	Black	3.28 nCi

Second Data Point 2/4/88

Smears were taken in same manner as for first data point. The environmental chamber temperature settings were both reduced to minimum when the bell was taken off to prevent the formation of condensation on the coupons. After the bell was reinstalled, the temperatures were reset to their original settings.

Coupon	Coupon Color	Smear Color	Activity
F999B	Black with Green Oxides	Medium Gray	1.47 nCi
F1010B	Orange Bronze with Black Wash	Dark Gray	3.47 nCi

Third Data Point 2/11/88

The smears and environmental chamber were handled in the same manner as done for the second data point. The smear colors were very similar this week compared with earlier ones. There is a definite color change occurring on the Du-Nb alloy plates as can be seen from earlier colors noted.

Coupon	Coupon Color	Smear Color	Activity
F1000A	Black except Pock marks Brown Some Green Oxides	Medium Gray	1.23 nCi
F1008A	Blue/Violet with light Black Wash Some Green Oxides	Medium Gray	2.76 nCi

Fourth Data Point

The final data points were taken using the same smear techniques used in taking earlier data points. On this last collection, a smear was taken on each side of all coupons. Extensive color notes were also made.

Coupon	Coupon Color	Smear Color	Activity
F998A	Black with extensive green deposits	Olive Green	10.25 nCi
F998B	Black with extensive green deposits	Olive Green	11.73 nCi
F999A	Black with traces of green deposits Pock marks were brown	Medium Gray	0.23 nCi
F999B	Black with traces of green deposits Pock marks were brown	Medium Gray	0.43 nCi
F1000A	Black with traces of green deposits Pock marks were brown	Medium Gray	0.55 nCi
F1000B	Black with traces of green deposits Pock marks were brown	Dark Gray	1.06 nCi
F1007A	Black with some brown traces	Medium Gray	1.04 nCi
F1007B	Black with some brown traces	Medium Gray	0.85 nCi
F1008A	Violet with Black Wash	Medium Gray	0.97 nCi
F1008B	Violet with Black Wash	Dark Gray with Green	3.20 nCi
F1010A	Violet with Black Wash	Dark Gray with Green	1.67 nCi
F1010B	Violet with Black Wash	Dark Gray with Green	1.42 nCi

Observations

At the end of the test the following notes were taken on the condition of the test apparatus and the coupons.

All of the plates had traces of olive green oxides on the edges where they came in contact with the SS coupon holder for the duration of the test.

The aluminum pan and roof assembly had some white corrosion present at the perimeter of the SS coupon holder footprint.

Coupon F998 was markedly different in appearance compared with all other coupons. It had extensive traces of olive green oxides all over its surfaces in addition to those traces noted above.

The DU coupons F999 and F1000 had a gun-metal blue luster when looking at reflections of their surfaces.

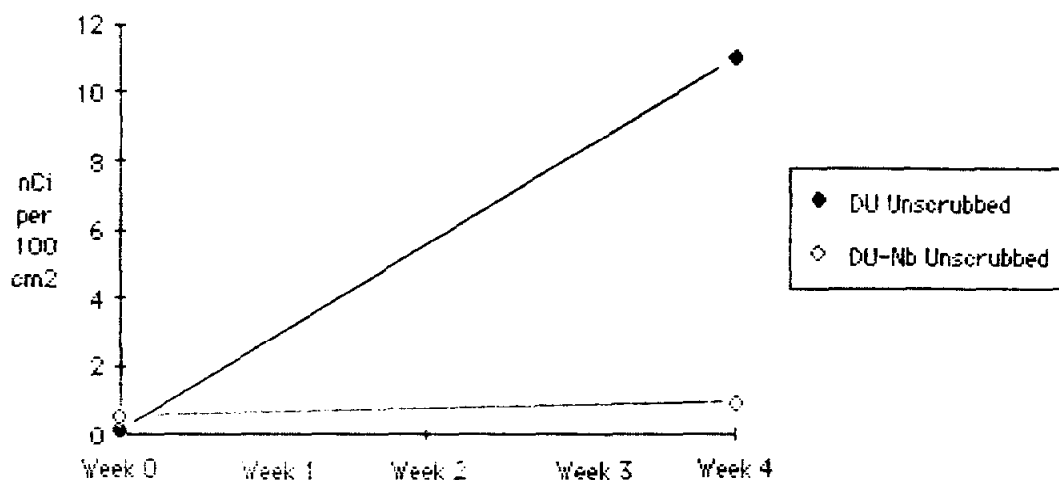
The DU-Nb coupons F1008 and F1010 had a violet luster when looking at reflections of their surfaces.

Both of the unscrubbed coupons F998 and F1007 had no luster and were generally a dull black.

Results

The contamination growth is plotted below as a function of time for the unscrubbed coupons and scrubbed coupons in graphs 1 and 2 respectively. All contamination data collected during is tabulated in Attachment

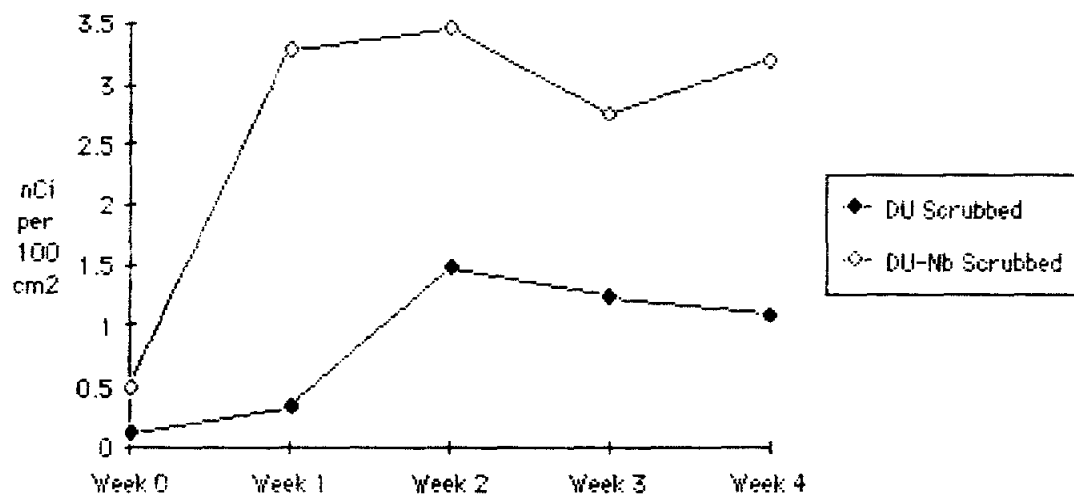
Unscrubbed Coupon Contamination Growth
January 20, 1988 through February 18, 1988



A.

Graph 1

Scrubbed Coupon Contamination Growth
January 20, 1988 through February 18, 1988



Conclusions

1. The unscrubbed DU coupon contamination levels increased by a factor of about 100 over the period of the test. The increase in contamination levels is attributed to the formation of the olive green oxide since the smear was only green. In general, this coupon presented the greatest contamination hazard for these test conditions.
2. The unscrubbed alloy coupons, despite their rougher surface, showed only a twofold increase in contamination levels measured.
3. The scrubbed DU coupons also showed an increase in contamination levels of about 50 times over the period of the test, although beginning and ending levels were lower than those of the alloy coupons.
4. The scrubbed DU-Nb coupons increased in contamination levels by an average factor of 39. The removable contamination was higher for these coupons by at least a factor of two compared with the DU coupons.
5. Based on the coupons colors noted for the scrubbed coupons, there is a definite difference in their composition.
6. No conclusions are drawn based on appearance of these coupons regarding corrosion rates.
7. After the first week, it appears that the contamination growth rate for both coupons is not markedly different.

Recommendations for Future Tests

Several things should be considered if future corrosion tests are to be performed.

1. The oxides of the coupons should be characterized to establish the type and quantity of the isotopes present. For a given mass of an oxides from each type of coupon, the activity could vary depending on the concentration of short-lived daughters in the respective samples.

2. Some method of measuring actual corrosion rates should be considered. The use of contamination levels as a measure of corrosion rate may be invalid because not all corrosion can be removed with a smear.
3. It may be desirable to prepare the coupons with a surface grinder to establish a uniform surface quality to eliminate surface quality as a factor. This may not be desirable however, if the surface qualities of the coupons are representative of surfaces of plates under consideration.

March 15, 1988

**SUBJECT: Sanding/"Car Wash Style" Uranium Plate
Cleaning Tests Performed on 1/26-28/88 -
2200 psi Sprayer**

Three tests were done with the 2200 psi sprayer unit. The purpose of these tests was to compare the effectiveness of a 2200 psi sprayer with the 500 psi sprayer tested on 1/21 and 1/22/88. One plate was only sprayed for a comparison with the 1/21/88 test. The the other was sanded with the orbital air driven sander and Scotchbrite pad and then sprayed for a comparison with the 1/22/88 test. Additionally, a part of one plate was wet sanded to check for cleaning efficiency by wet sanding.

The sprayer was reported to be a 2200 psi unit. The pressure gage mounted on the unit, however, indicated that only about 1300 psi was actually developed.

One major difference in the 2200 psi sprayer is that the volume flow rate of water was significantly higher than that of the 500 psi sprayer. The 500 psi sprayer generated approximately 20 gallons of water waste for two plate test while the 2200 psi sprayer generated about 60 gallons of water waste for two and part of a third plates. For one and part of another plate, the sprayer operator stopped the spray as he repositioned the wand in an effort to conserve water. In a closed system a higher flow rate will not lead to more waste. However, care must be taken in the design of the water system to ensure that the higher water flow rates can be handled while permitting adequate uranium oxide settling/separation time.

The waste water generated was analysed for uranium oxide activity level and particle size and the results are discussed in a separate memo.

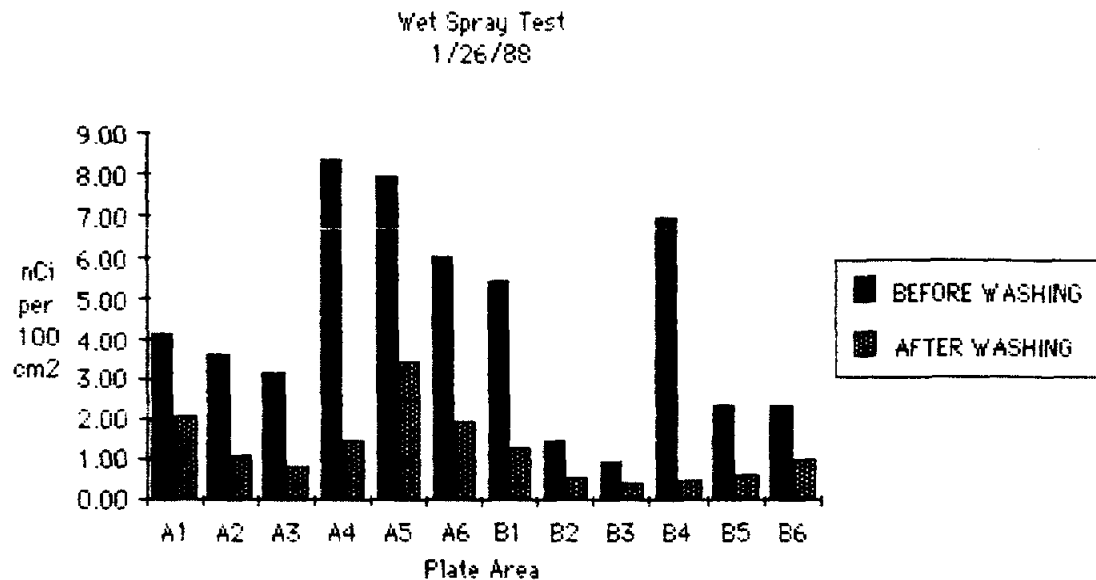
Test 1 - Wet Spray Test

Both sides of an IFH plate was smeared (12 areas, 6 per side) before and after washing with the 2200 psi sprayer. Contamination levels were reduced by about 71%. The results are shown in Table 1 and Graph 1 below.

Plate F994 Plate Area	Contamination Levels Before Washing (nCi/100cm ²)	Contamination Levels After Washing (nCi/100cm ²)
A1	4.15	2.11
A2	3.65	1.06
A3	3.14	0.82
A4	8.40	1.52
A5	7.96	3.41
A6	6.06	1.98
B1	5.47	1.26
B2	1.50	0.54
B3	0.96	0.40
B4	6.98	0.51
B5	2.39	0.63
B6	<u>2.39</u>	<u>1.00</u>
Average Levels	4.42	1.27

Table 1

No air sampling was done because of the nature of the test.



Graph I

Test 2 Dry Sanding/Spray Test

Smears were taken on both sides of an IFH plate (12 areas, 6 per side) before sanding, before washing, and after washing.

The plate was dry sanded in the vertical orientation because of the restrictions on plate handling in the test spray booth. Those performing the test wore North half face respirators and personal air monitors. The high volume air sampler was also used to sample the air.

The air sample data is presented below from the samples taken.

Person	Activity	% of Standard
Darby	<1.06 E-10 uCi/ml	<106%
Miller	<1.65 E -10 uCi/ml	<110%
High Volume Air Sampler	5.99 E -11 uCi/ml	59%

The spray pattern varies with distance the nozzle is held from the plate. The pattern is fan shaped and is rather narrow, about 1 to 3 inches as I observed during the test. The angle of the spray with respect to the plate varied as the wand was moved high and low to reach all areas of the plate.

The results of this test are shown in Table II and Graph II below.

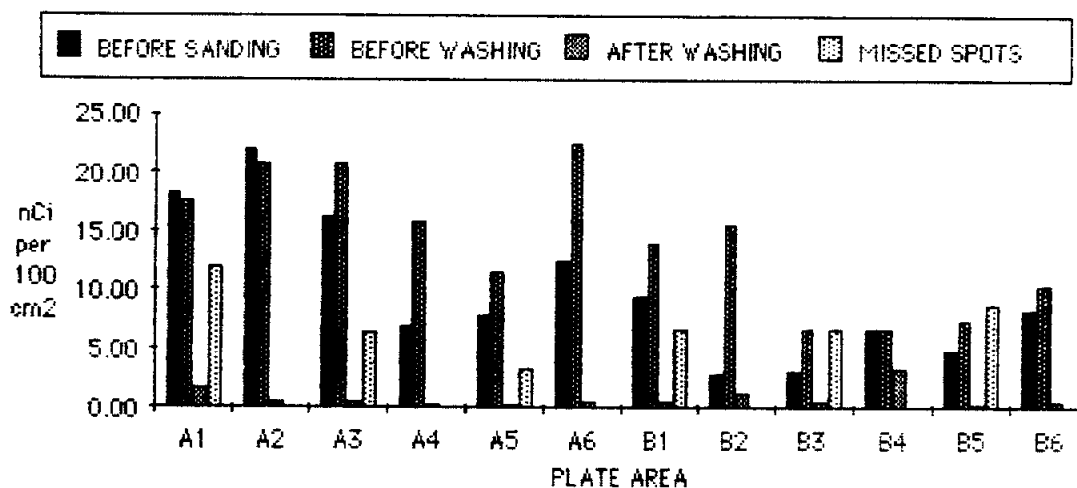
Plate F995

Plate Area	Before Sanding (nCi/100cm ²)	Before Washing (nCi/100cm ²)	After Washing (nCi/100cm ²)	Missed Spots
A1	18.36	17.60	1.73*	11.66
A2	22.07	20.7	0.76	
A3	16.38	20.69	0.62	6.49
A4	7.00	15.74	0.49	
A5	7.81	11.51	0.39	3.47
A6	12.35	22.65	0.69	
B1	9.52	13.91	0.67	6.82
B2	2.87	15.64	1.35*	
B3	3.07	6.85	0.66	6.70
B4	6.79	6.85	3.34*	
B5	5.01	7.50	0.43	8.86
B6	<u>8.34</u>	<u>10.48</u>	<u>0.60</u>	
Average Levels	9.96	14.18	0.98*	7.37

*Attributed to missed areas - the average levels not including these points is 0.59 nCi/100cm².

Table II

DRY SANDING/SPRAY TEST
MARCH 27, 1988



Graph II

It was discovered during the course of these tests that even if a lot of care is taken, the wand of the sprayer cannot be relied upon to clean all areas of the plate. Smears in table II were taken in the designated areas of the plate map, but in areas which looked clean. A second group of smears were taken

in areas which looked 'dirty' and provided fairly conclusive proof that not all areas of the plate were washed with the sprayer. A wand of some sort with multiple nozzles would provide better assurance that all areas of the plate were cleaned.

Loose contamination levels were reduced by about 94% if the three astericked areas are not considered and by about 90% if they are considered.

Test 3 Wet Sanding/Spray

Wet sanding was done on one side of an IFH plate over four of the mapped plate areas. The bottom of the spray booth was used to determine how much of the plate was sanded to prevent spreading DU laden water off of the table.

During this test it was noted that the orbital sander would throw small quantities of water a short distance away from the sander. The sleeves of the sander operator were sprayed with small traces of UO₂ laden water. It was also noted that the sander was not always held flat against the plate. This was due in part to the awkward position the sander operator stood in to reach the plate. The sander tended to throw water when it was not held flat against the plate.

In earlier tests, about 90 seconds per side was the time spent sanding plates. In this test, about 5 minutes was spent sanding about two-thirds of one side of the plate.

The results of this test are given in Table III below.

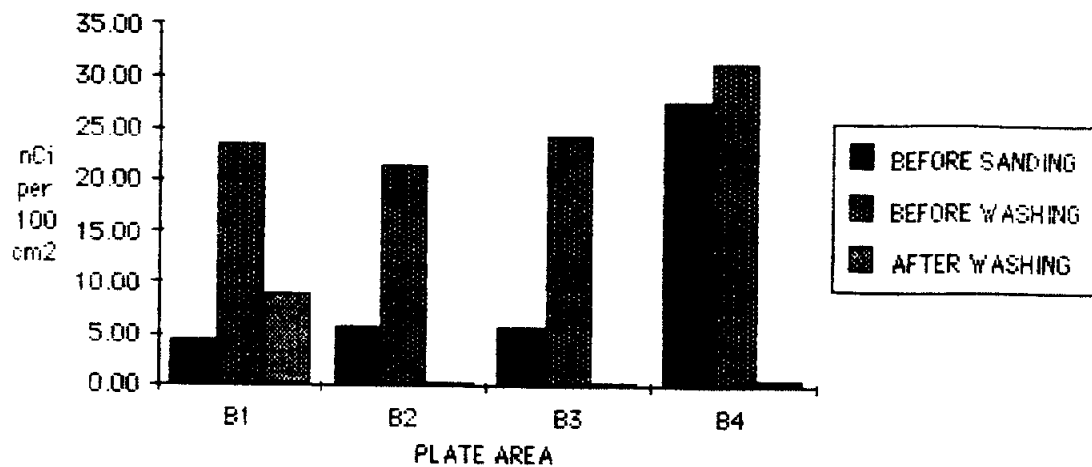
Plate F993

Plate Area	Before Sanding (nCi/100cm ²)	Before Washing (nCi/100cm ²)	After Washing (nCi/100cm ²)
B1	4.56	23.38	8.90 [!]
B2	5.69	21.30	0.36
B3	5.69	24.26	0.40
B4	<u>27.75</u>	<u>31.41</u>	<u>0.67</u>
Average	10.92	25.09	2.59 [!]
Levels			

! This smear was very probably taken from a spot missed by the sprayer. The average level discounting this result is 0.46 nCi/100cm².

Table III

WET SANDING/SPRAY TEST
1/28/88



Graph III

The contamination levels noted before washing (after sanding) in the wet test are consistently high and also some of the highest seen to date. This is attributed to two factors.

1. The longer time spent by the sander operator on the plate and
2. The smears taken for this test were wet. Wet smears have a better collection efficiency. (The smears were allowed to dry before they were counted.)

Conclusions

The 500 psi sprayer reduced loose contamination levels by about 56%. The 2200 psi sprayer reduced levels by 71%. Both of these results were obtained before it was discovered and verified that areas of the plates could be missed. It appears that the higher pressure sprayer is more effective at contamination removal.

The dry sanding/spraying test with the 500 psi sprayer reduced contamination levels by about 76% while the 2200 psi sander/sprayer combination reduced levels by about 94%.

Dry sanding in the vertical position could build up to very undesirable levels after a few plates are sanded. Dry sanding in the vertical position is not considered an acceptable sanding method.

Wet sanding in the horizontal plate is much more desirable than dry sanding because there is far less potential for DU dust to become airborne. In every dry sanding test except the first one when low volume airflow monitoring devices were used, measurable dust was found. (Due to manpower shortages on the day of the wet sanding test, no air sample were taken. The North HEPA filter respirators were worn as a precaution.)

Wet sanding followed by spraying with a high pressure sprayer is the most effective cleaning method tried to date. Contamination levels were reduced by about 96% although it is not known how the longer sanding time affected this outcome. The much reduced potential for airborne activity generation makes this method most desirable found to date for cleaning uranium plates.

As noted above, small quantities of water were thrown as far as 10 inches during the course of the wet sanding test. It would be prudent to have the sanding operator and others in the vicinity of the wet sanding operation wear additional protective clothing in the form of tyvek sleeves, face shields and hoods or hair nets. These items would protect workers from water spray which could be thrown from the sander.

March 16, 1988

**SUBJECT: DU Coupon Immersion Test - February 5th to
18th, 1988**

Background

This test was conceived and performed in order to determine if DU would corrode when immersed in deionized water. It has been suggested that it may be possible to remove some elemental metal in the process of wet sanding uranium and the proposed wet sanding and water spray booth might collect the elemental uranium generated by the sanding process. It was feared that when this elemental metal is eventually dried during waste water processing, the elemental metal could burn and start a fire.

Test Preparation - 2/5/88

Two coupons of DU were scrubbed with Scotchbrite pads and alcohol. One coupon (F1009) was a 1/4" DU-Nb alloy and the other (F992) was a 1/8" DU coupon.

The DU coupon was silvery in appearance at the beginning of the test. The DU-Nb alloy coupon was silvery but had pits from which oxides could not be completely removed.

The two coupons of DU were immersed in deionized water. The beginning contamination level on the DU-Nb alloy coupon was 0.15 nCi and the contamination level on the DU coupon was not detectable.

First Observation - 2/8/88

The coupons were checked for color change on February 8th. The DU coupon was orange/bronze in color and the DU-Nb alloy coupon was yellow/bronze. The pits on the DU-Nb alloy coupon had become very black relative to their appearance on February 5th.

Second Observation - 2/18/88

The coupons were removed from the water on February 18th and the following observations were made.

The DU coupons had a brass/bronze color with a light gray wash. Some very small pits (~1/16") of black oxide were apparant and these were surrounded by 1/4" rings of olive green oxides. A smear was taken on each side of the DU coupon. The smears were medium gray in color. The activity found on these smears was 0.42 and 0.51 nCi. It was estimated that $\leq 5\%$ of the 1/8" coupon was covered with these oxides.

The DU-Nb alloy coupon had much more oxides in general. 50% of one side of the coupon was completely covered with olive green oxides which seemed to be present in circles concentric with the large pits noted at the beginning of the test. The black centers no longer appeared as pits but the black oxides were mounded up above the surface of the plate. These black oxides appeared to be very loose. The reverse side was similar except that only 20% of the area was covered with olive green oxides.

The smear color on the DU-Nb alloy coupon was olive green/yellow/light gray. Contamination levels on these smears were 12.63 and 0.97 nCi.

There was some similarity in the appearance of the pits on the DU and Du-Nb alloy coupons except for sizes and areas as described above. In a comparison of the areas not covered with oxides on these coupons, the DU-Nb alloy actually looked better in appearance; that is, the back oxide wash on the bronze was much lighter than that noted on the DU coupon.

Conclusions

This test shows that elemental uranium does oxidize in water. The corrosion rate appears to be a function of the surface quality because corrosion was most intense in the pitted areas. The smooth areas did oxidize however, as was evident by the color change in those areas.

This test was performed in deionized water which sat virtually undisturbed for the duration of the test. The water which drains from the spray booth will be very agitated and will introduce more oxygen into the collection tank as a result. It is very probable that corrosion of any elemental uranium which enters the collection tank will be accelerated because of the presence of even higher levels of oxygen created by agitation.

Based on these findings, there should be no reason to expect that small particles of elemental uranium which are removed by sanding and drain to the collection tank will remain unoxidized and start burning when they are eventually dried.

March 18, 1988

SUBJECT: Corrosion Test in Dry Nitrogen Atmosphere

The purpose of this test was to determine if uranium corrodes in a dry nitrogen atmosphere at normal room temperatures. Since uranium corrosion in air is readily identifiable by a rapid color change, it was assumed that contamination smears would not be required to determine if the uranium had corroded.

Test Preparation 1/19 and 1/20/88

Two uranium coupons were scrubbed on the afternoon of 1/19/88 with Scotchbrite pads and alcohol to remove all oxides. One coupon (F992) 1/8" X 2" X 3" was a DU coupon and the other (F1009) was a 1/4" X 2" X 3" DU-Nb alloy coupon.

Both coupons were silvery in appearance. In addition, the DU-Nb alloy coupon had crevices containing black oxides which could not be removed.

The coupons were left in ambient air (75°F, 27% R.H.) overnight and were checked in the morning.

After sitting overnight, (approximately 16 hours), both coupons had taken on a bronze color. The DU-Nb coupon also had a light gray wash of color.

Both coupons were rescrubbed with Scotchbrite and alcohol and were immediately placed in a plastic bag. The bag was almost completely sealed; a slight opening was left in the top of the bag to permit positive flow of N₂ gas out of the bag. The N₂ gas flow into the bag was set at ≥ 0.5 lpm for approximately five minutes to purge all O₂ from the bag. The N₂ flow was then set to about 0.1 lpm for the duration of the test.

First Observation 1/28/88

The coupons were inspected through the bag; they were not removed from the N₂ atmosphere. The coupons were still silvery in color; they had not changed in appearance from the day they were loaded into the bag.

Second Observation 2/4/88

The coupons were inspected and this time they appeared to be noticeably blackened. The coupons were removed from the bag and it was confirmed that they had corroded. It is not known if the corrosion was UN₂ or UO₂.

Some checking was done to find if the N₂ supply had been interrupted. It was discovered that over the preceding weekend, the N₂ dewar had several low pressure alarms. The demand for N₂ had increased due to some operation with the test beam cryostat. The N₂ system at NWA is split into at least two headers and the pressure in these headers can be adjusted. There is a good possibility that the header used to feed the test bag was isolated. The end result is that the coupons may have been exposed to air for several days.

Conclusions

Based on the first observation, it is suspected that corrosion is arrested in the N₂ atmosphere. The results, however, are in no way considered conclusive. The test should be performed again for an extended period of time (several weeks) with an uninterrupted N₂ supply to confirm whether or not corrosion occurs.

March 21, 1988

SUBJECT: Uranium Oxide in Water - Settling Test

The purpose of this test was to determine the settling rate of uranium oxides in an undisturbed column of water.

Test Preparation

On 3/4/88, an IFH uranium plate was hand cleaned using a Scotchbrite pad and water. A lead brick was used to apply pressure to the pad to provide for aggressive cleaning of the plate. The Scotchbrite pad was rinsed "clean" in a pail of water. The pail was also used to collect deionized water used to rinse the DU plate after scrubbing.

Several gallons of water were collected and the collected water was heavily loaded with black oxides.

The water was allowed to settle over the weekend. On 3/7/88, the supernatant (about two to three gallons) was collected from the pail. About 325 ml of water/oxide mixture was removed from the bottom of the bucket. The activity of the supernatant was found to be 20 pCi/ml while the settled mixture activity was 5,420 pCi/ml.

The tank was marked at levels 0", 6", 12", and 24", the 0" level being at the water surface.

On 3/8/88 a "fishtank" 6" X 6" X 36" was filled with deionized water to about 28". The water in the "fishtank" was crystal clear. The 325 ml mixture of UO₂ and water was slowly poured into the column at time T = 0. Due to the inertia of the oxide mixture from pouring, a black inverted cone-like shape developed in the column to roughly the 18" level. After just a few minutes the column was entirely black and opaque.

Data Collection

5 ml samples were taken from the 6", 12", 18", and 24" levels at 15 minute intervals from T = 15 minutes until T = 2 hours. The four samples were taken again at T = 4 hours, T = 8 hours, T = 23 hours, T = 50 hours, and T = 77 hours. At T = 150 hours, samples were taken at the 6" 12", and 18" levels only. The "fishtank" had developed a leak so that the 24" level was not available.

In addition to the 5 ml samples, 250 ml samples were taken for particle size analysis at the 6", 12", 18", and 24" levels at T = 24 hours. These samples were checked only for 3.0, 1.0, and 0.8 μ m particles.

At T = 150 hours, a 250 ml sample for particle analysis was taken at the 9" level (the column was only 19" at this point). This sample was checked for 1.0, 0.8, 0.6, 0.4, and 0.1 μ m particles.

A 250 ml sample was also taken from the supernatant collected in the second pail and analysed for 3.0, 1.0, 0.8, 0.6, 0.4, and 0.1 μ m particles.

All rinse water from the collection of samples was retained in a second pail for possible reuse.

5 ml Sample Results

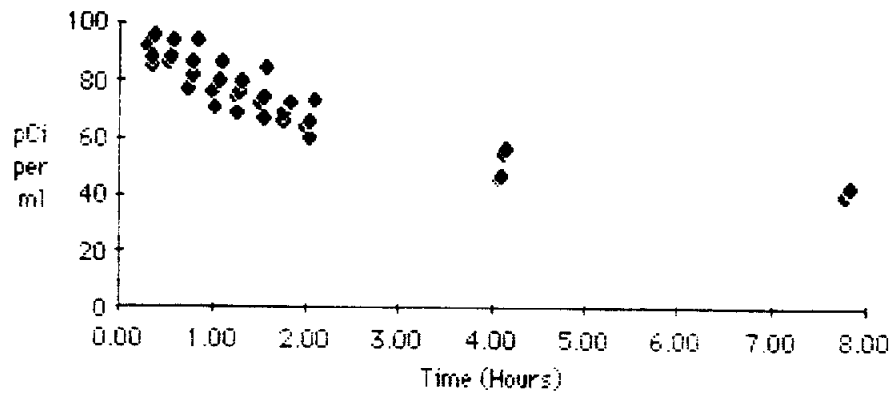
The sample data is listed in Table 1 and is presented in Graphs I through VI below.

Sample Number	Date /Time	Size (ml)	Depth (inches)	Planchette Number	Activity (nCi)	Sp. Activity pCi/ml
1	3/8/88 9:12	4.7	6	2	0.43	91
	3/8/88 9:15	4.9	12	3	0.42	86
	3/8/88 9:16	5	18	4	0.44	88
	3/8/88 9:18	5	24	5	0.48	96
	3/8/88 9:26	5	6	6	0.43	86
2	3/8/88 9:27	5	12	7	0.43	86
	3/8/88 9:29	5	18	8	0.44	88
	3/8/88 9:30	5	24	9	0.47	94
	3/8/88 9:40	4.95	6	10	0.38	77
	3/8/88 9:42	5	12	11	0.41	82
3	3/8/88 9:42	5	18	12	0.43	86
	3/8/88 9:45	5	24	13	0.47	94
	3/8/88 9:55	5	6	14	0.38	76
	3/8/88 9:57	4.95	12	15	0.35	71
	3/8/88 9:59	5	18	16	0.40	80
4	3/8/88 10:01	5	24	17	0.43	86
	3/8/88 10:10	5	6	18	0.37	74
	3/8/88 10:11	5	12	19	0.34	68
	3/8/88 10:12	4.85	18	20	0.37	76
	3/8/88 10:14	5	24	2	0.40	80

Sample Number	Date /Time	Size (ml)	Depth (inches)	Planchette Number	Activity (nCi)	Sp. Activity pCi/ml
6	3/8/88 10:25	5	6	22	0.36	72
	3/8/88 10:27	4.95	12	23	0.33	67
	3/8/88 10:28	5	18	24	0.37	74
	3/8/88 10:30	5	24	25	0.42	84
7	3/8/88 10:40	5	6	26	0.33	66
	3/8/88 10:41	5	12	27	0.34	68
	3/8/88 10:43	5	18	28	0.36	72
	3/8/88 10:45	5	24	29	0.36	72
8	3/8/88 10:55	5	6	30	0.32	64
	3/8/88 10:57	5	12	31	0.30	60
	3/8/88 10:57	4.9	18	32	0.32	65
	3/8/88 11:00	4.95	24	33	0.36	73
9	3/8/88 12:59	5	6	34	0.23	46
	3/8/88 13:01	4.95	12	35	0.23	46
	3/8/88 13:03	5	18	36	0.27	54
	3/8/88 13:04	5	24	37	0.28	56
0	3/8/88 16:39	5	6	39	0.20	40
	3/8/88 16:40	5	12	40	0.20	40
	3/8/88 16:42	5	18	41	0.20	40
	3/8/88 16:45	4.6	24	42	0.20	43
11	3/9/88 8:00	5	6	43	0.10	20
	3/9/88 8:03	5	12	44	0.10	20
	3/9/88 8:05	5	18	45	0.10	20
	3/9/88 8:07	5	24	46	0.10	20
12	3/9/88 10:09	4.95	6	48	0.08	16
	3/10/88 10:11	5	12	49	0.08	16
	3/10/88 10:13	5	18	50	0.07	14
	3/10/88 10:15	5	24	51	0.07	14
13	3/11/88 14:19	4.9	6	52	0.04	8
	3/11/88 14:21	5	12	53	0.05	10
	3/11/88 14:23	5	18	54	0.05	10
	3/11/88 14:24	5	24	55	0.05	10
14	3/14/88 14:06	5	6	56	0.02	4
	3/14/88 14:09	4.65	12	57	0.02	4
	3/14/88 14:12	5	18	58	0.03	6

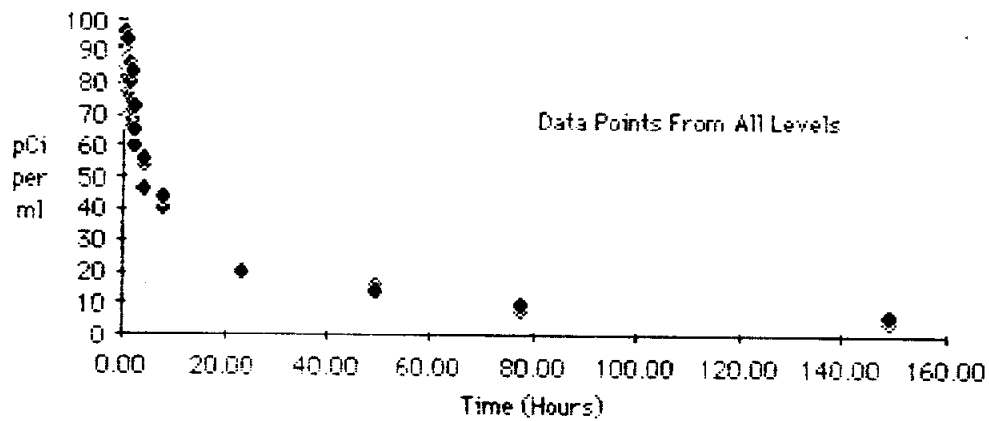
Table 1

Uranium Oxide Settling Test
Data After First Eight Hours
3/8/88



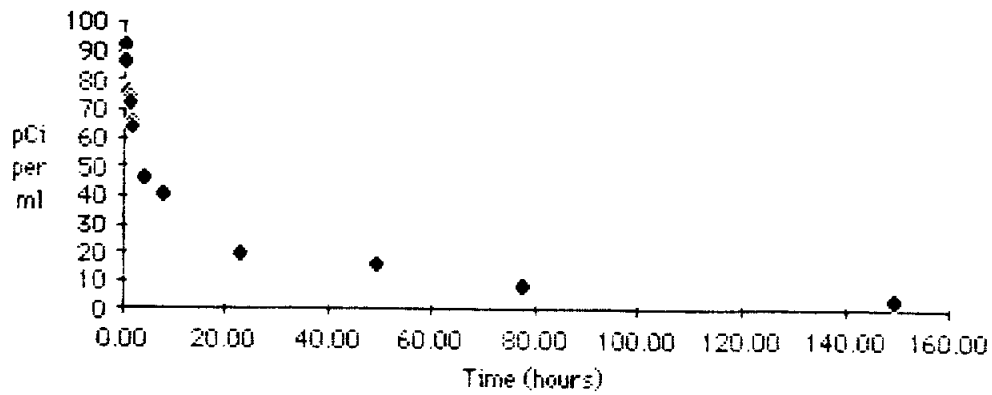
Graph I

Uranium Oxide Settling Test
3/8/88 to 3/14/88



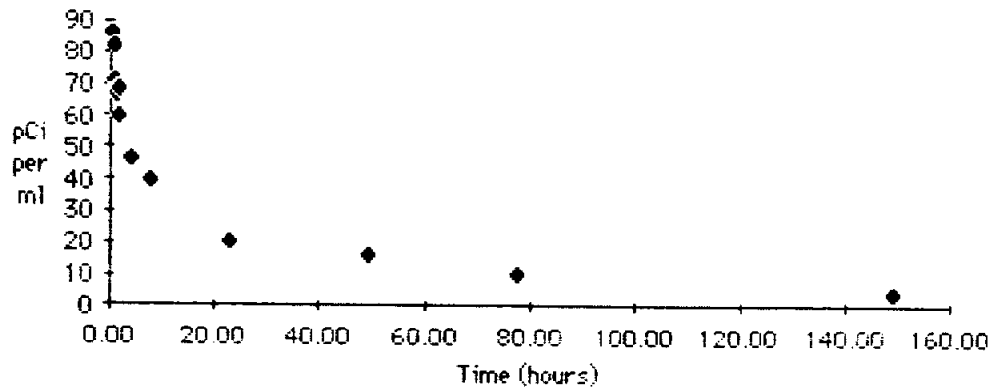
Graph II

Uranium Oxide Settling Test
3/8/88 to 3/14/88
6" Level Data



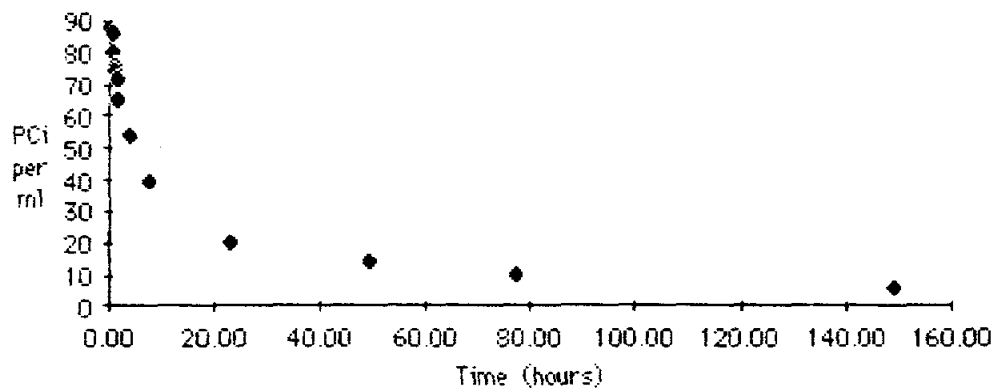
Graph III

Uranium Oxide Settling Test
3/8/88 to 3/14/88
12" Data



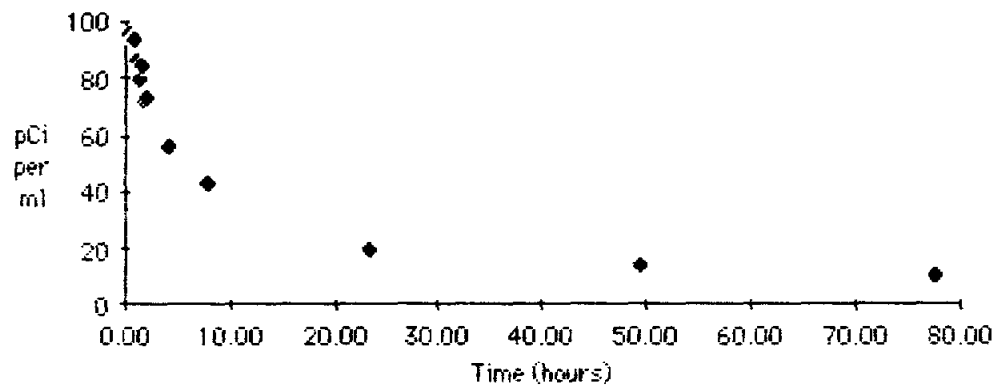
Graph IV

Uranium Oxide Settling Test
3/8/88 to 3/14/88
18" Level Data



Graph V

Uranium Oxide Settling Test
3/8/88 to 3/14/88
24" Level Data



Graph VI

250 ml Sample Results

The results of the 250 ml samples are shown in Table 2 and in bar graphs below.

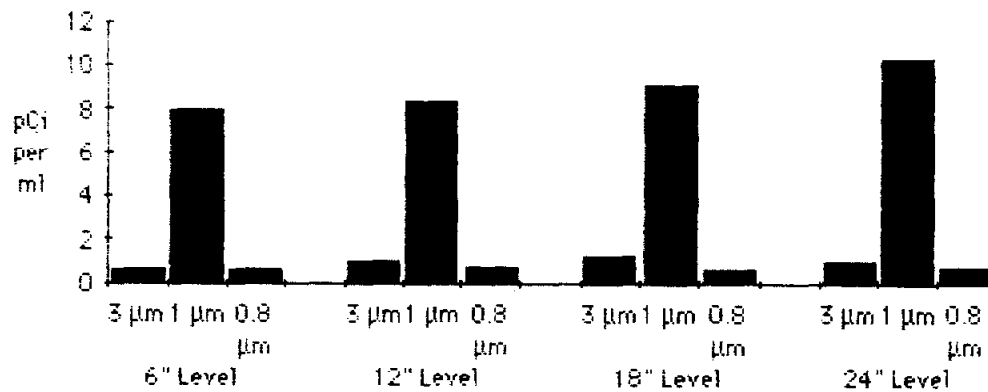
Graph VII shows the relative quantities of 3.0, 1.0 and 0.8 μ m particles at the 6", 12", 18", and 24" levels at T = 24 hours.

Sample Number	Filter Size (µm)	Date /Time	Level (in.)	Activity (pCi)	SP.ACT. (pCi/ml)	ΣS.A. (pCi/ml)	Gross Activity
43	3.0	3/9/88 8:00	6	170	0.68		
43	1.0	3/9/88 8:00	6	1990	7.96		
43	0.8	3/9/88 8:00	6	170	0.68	9.32	20
44	3.0	3/9/88 8:03	12	250	1.00		
44	1.0	3/9/88 8:03	12	2070	8.28		
44	0.8	3/9/88 8:03	12	180	0.72	10	20
45	3.0	3/9/88 8:05	18	300	1.20		
45	1.0	3/9/88 8:05	18	2250	9.00		
45	0.8	3/9/88 8:05	18	140	0.56	10.76	20
46	3.0	3/9/88 8:07	24	260	1.04		
46	1.0	3/9/88 8:07	24	2580	10.32		
46	0.8	3/9/88 8:07	24	190	0.76	12.12	22
47	3.0	3/9/88 7:56	B*	20	0.08		
47	1.0	3/9/88 7:56	B*	320	1.28		
47	0.8	3/9/88 7:56	B*	300	1.20		
47	0.6	3/9/88 7:56	B*	1780	7.12		
47	0.4	3/9/88 7:56	B*	590	2.36		
47	0.1	3/9/88 7:56	B*	280	1.12	13.16	12
59	1.0	3/14/88 14:25	18	480	1.92		
59	0.8	3/14/88 14:25	18	170	0.68		
59	0.6	3/14/88 14:25	18	300	1.20		
59	0.4	3/14/88 14:25	18	100	0.40		
59	0.1	3/14/88 14:25	18	110	0.44	4.64	6

B* - Bucket

Table 2

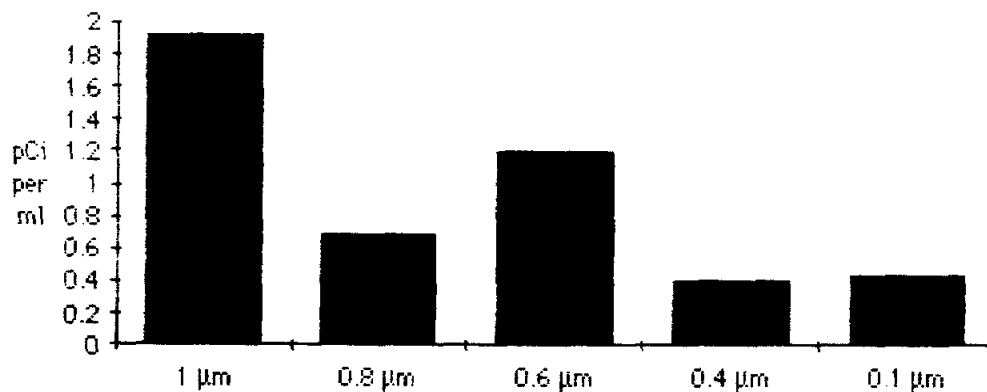
Uranium Oxide Settling Test
Particle Size Determination After 24 Hours
at 6", 12", 18", and 24" Levels
3/9/88



Graph VII

Graph IX shows the particle size at the 9" level at the conclusion of the test. It was assumed that the 3.0 µm particles would not be present and were not specifically analysed.

Uranium Settling Test
Particle Size Analysis at 9" Level
at Conclusion of the test 3/14/88

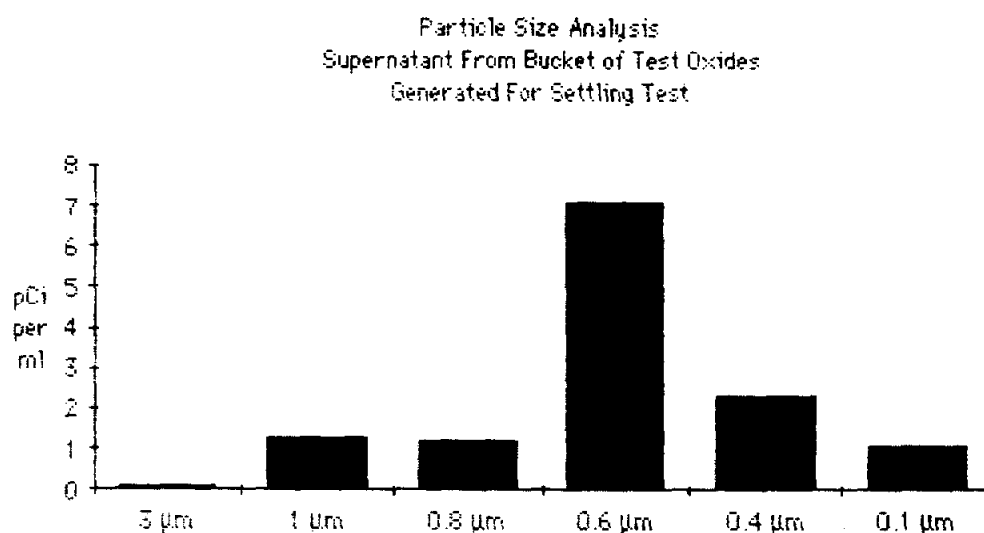


Graph VIII

Graph IX shows the concentrations of particle sizes of the material not used in the column test but generated by wet scrubbing the plate. The sample of these particles came from the two to three gallons of supernatant. A rough

guess, assuming that these particles were concentrated in the initial 325 ml pour and did not ever settle during the test, would be that these oxides would be present at about 75% of the concentrations shown in Graph IX. This is an incremental increase above the concentrations present but not identified in the filter paper analysis discussed above.

It was assumed that the 3.0 μm and larger particles had settled out; these were not analysed.



Graph IX

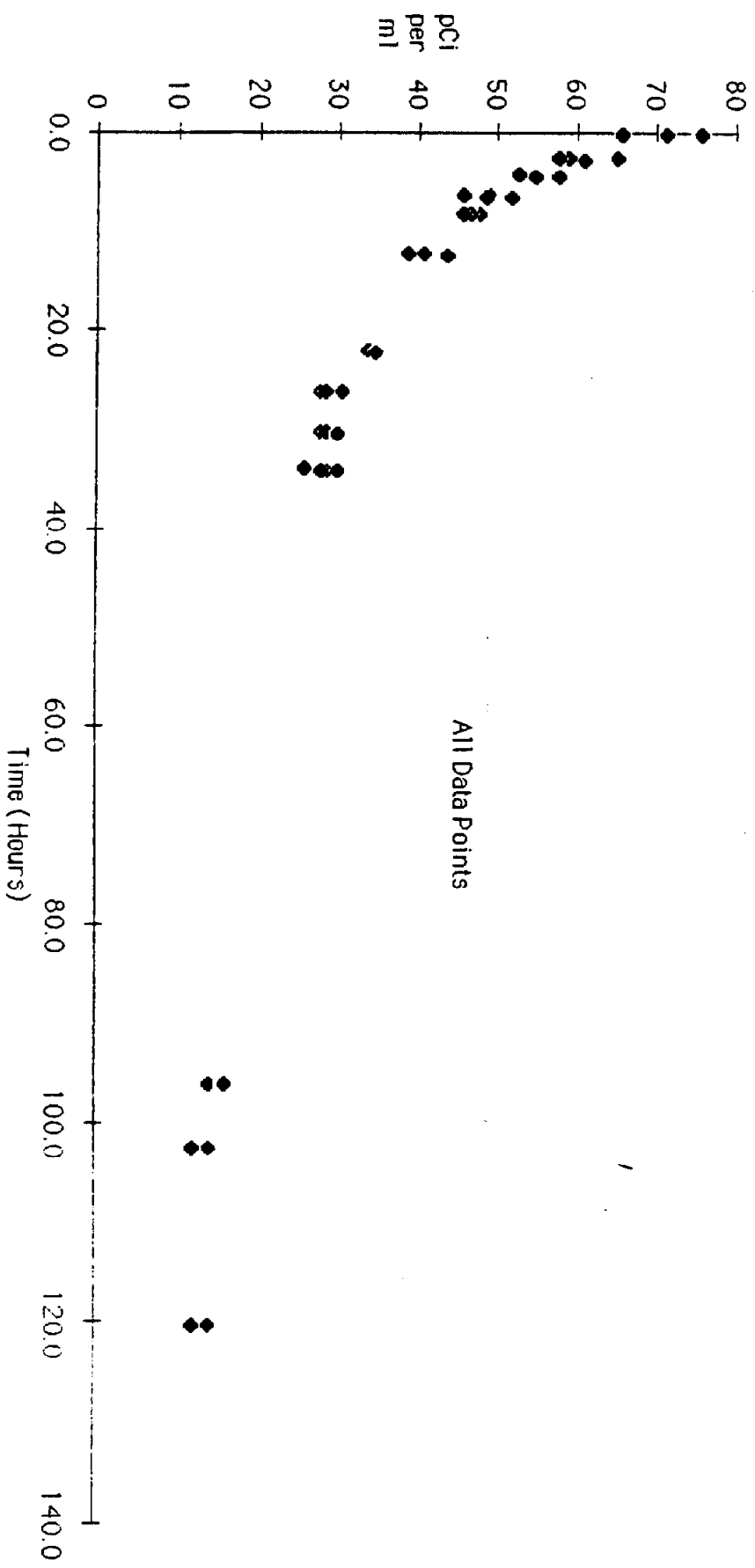
Conclusions

The low end of the range of particles produced by wet sanding is about 0.1 μm based on the fairly good agreement between the filter paper analysis and 5 ml sample result from the supernatant (see table 2). Earlier tests indicate that 1 μm particles are at the low end of the range of particles produced by dry sanding.

Differences in specific activity found between the filter paper analyses and the 5 ml samples at each of the four levels at $T = 24$ hours (see Table 2) indicate that as much as 50% of the activity in the water is due to particles smaller than 0.8 μm . It is unfortunate that no analyses were done for smaller particles at $T = 24$ hours. This should be done as soon as the opportunity to do so presents itself.

Conclusions to be drawn regarding settling rates are left to those designing the water collection system.

Second Uranium Settling Test

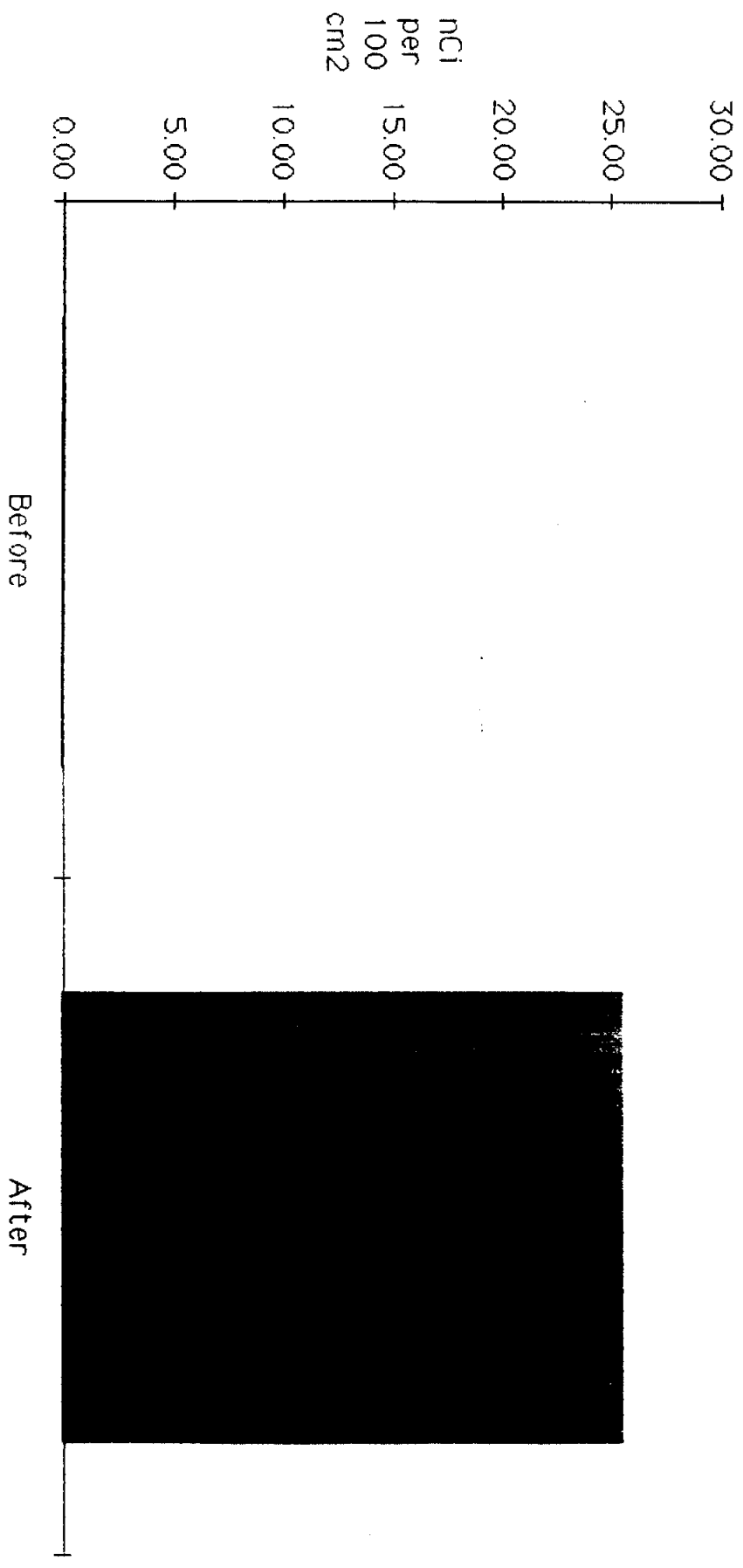


SAMPLE #	VOLUME	DEPTH (INCHES)	TIME	ACTIVITY (HPI)	PCI	PCI/HH	
93	5	6	3/17/88 8:26	0.33	330	66	0.0
94	4.9	12	3/17/88 8:28	0.37	370	76	0.1
95	5	18	3/17/88 8:30	0.38	380	76	0.1
96	4.9	24	3/17/88 8:30	0.35	350	71	0.1
97	4.9	6	3/17/88 10:49	0.29	290	59	2.4
98	4.9	12	3/17/88 10:51	0.32	320	65	2.4
99	5	18	3/17/88 10:53	0.29	290	58	2.5
100	4.9	24	3/17/88 10:55	0.30	300	61	2.5
101	4.9	6	3/17/88 12:33	0.26	260	53	4.1
102	4.9	12	3/17/88 12:34	0.27	270	55	4.2
103	4.9	18	3/17/88 12:36	0.27	270	55	4.2
104	5	24	3/17/88 12:38	0.29	290	58	4.2
105	5.1	6	3/17/88 14:37	0.25	250	49	6.0
106	4.8	12	3/17/88 14:40	0.22	220	46	6.3
107	4.9	18	3/17/88 14:42	0.24	240	49	6.3
108	5	24	3/17/88 14:44	0.26	260	52	6.3
109	4.8	6	3/17/88 16:25	0.22	220	46	8.0
110	4.8	12	3/17/88 16:26	0.23	230	48	8.0
111	4.7	18	3/17/88 16:27	0.22	220	47	8.0
112	5	24	3/17/88 16:30	0.23	230	46	8.1
113	4.9	6	3/17/88 20:27	0.19	190	39	12.0
114	4.9	12	3/17/88 20:29	0.20	200	41	12.1
115	5	18	3/17/88 20:30	0.22	220	44	12.1
116	5	24	3/17/88 20:33	0.22	220	44	12.1
117	5	6	3/18/88 6:20	0.17	170	34	21.9
118	4.9	12	3/18/88 6:21	0.17	170	35	21.9
119	4.9	18	3/18/88 6:23	0.17	170	35	22.0
120	4.9	24	3/18/88 6:25	0.17	170	35	22.0
121	4.9	6	3/18/88 10:32	0.15	150	31	26.1
122	5	12	3/18/88 10:33	0.14	140	28	26.1
123	4.9	18	3/18/88 10:34	0.14	140	29	26.2
124	4.9	24	3/18/88 10:36	0.14	140	29	26.2
125	5	6	3/18/88 14:32	0.14	140	28	30.1
126	4.9	12	3/18/88 14:34	0.14	140	29	30.2
127	5	18	3/18/88 14:35	0.15	150	30	30.2
128	5	24	3/18/88 14:37	0.15	150	30	30.2
129	5	6	3/18/88 18:21	0.13	130	26	33.9
130	4.9	12	3/18/88 18:23	0.14	140	29	34.0
131	5	18	3/18/88 18:24	0.15	150	30	34.0
132	5	24	3/18/88 18:26	0.14	140	28	34.0
133	4.8	6	3/21/88 8:24	0.07	70	15	96.0
134	5	12	3/21/88 8:25	0.07	70	14	96.0
135	5	18	3/21/88 8:27	0.08	80	16	96.0
136	4.9	24	3/21/88 8:29	0.08	80	16	96.1
137	5	6	3/21/88 14:39	0.07	70	14	102.2
138	5	12	3/21/88 14:43	0.07	70	14	102.3
139	5	18	3/21/88 14:45	0.06	60	12	102.3
140	5	24	3/21/88 14:47	0.07	70	14	102.4
141	5	6	3/22/88 8:40	0.07	70	14	120.3
142	5	12	3/22/88 8:42	0.06	60	12	120.3
143	5	18	3/22/88 8:44	0.06	60	12	120.3
144	5	24	3/22/88 8:46	0.07	70	14	120.4

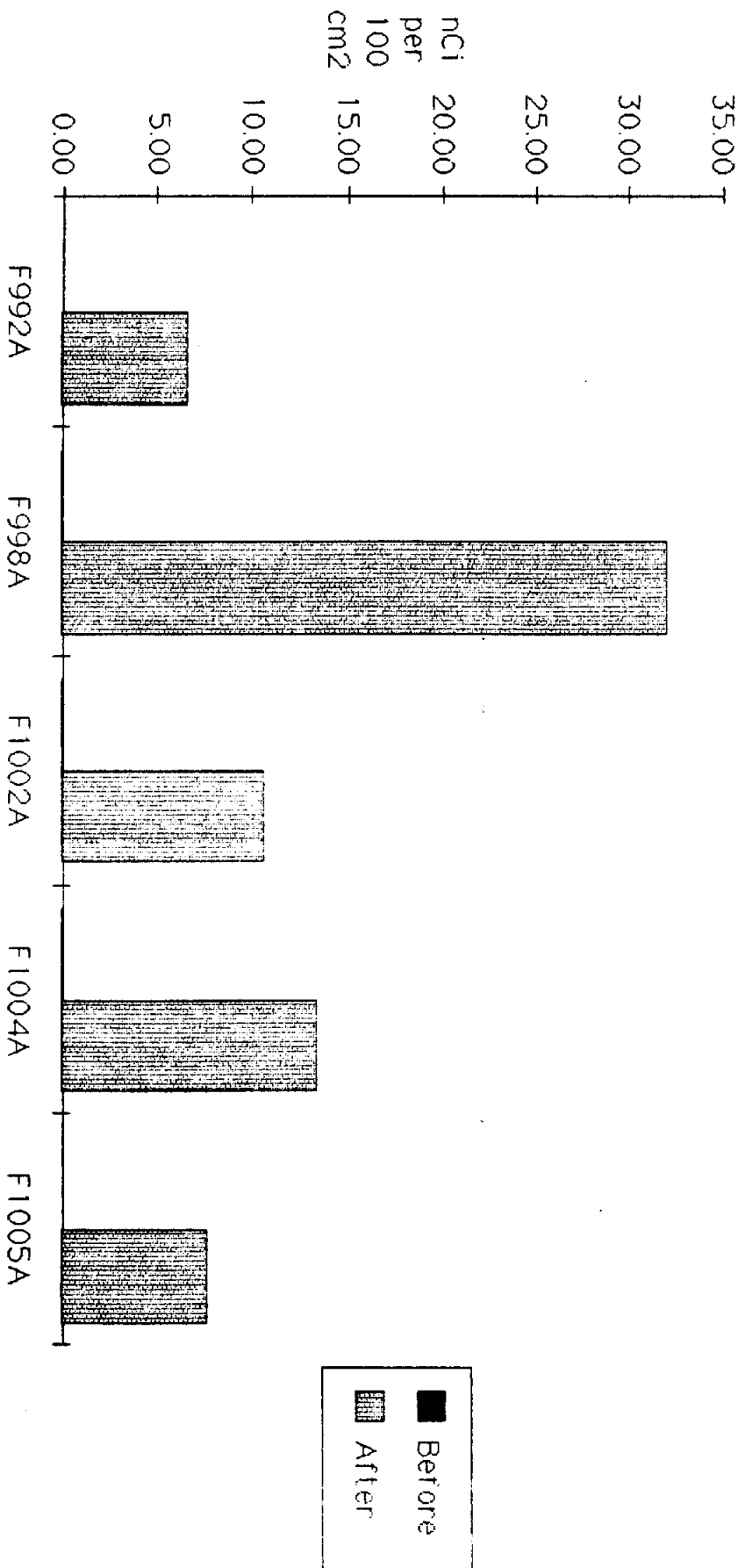
Second Settling Test		Particle Size Data		
Filter Size	Sample Size (ml)	Activity (NCI)	Activity (pci)	Sp. Act. (pci/ml)
3.0	250	0.03	30	0.12
1.0	250	2.24	2240	8.96
0.8	250	0.12	120	0.48
0.6	250	0.12	120	0.48
0.4	250	0.12	120	0.48
0.1	250	0.19	190	0.76
Total Specific Activity				11.28
Measured Gross Activity - 5 ml Sample				12

Coupon I.D.	First Smear	Second Smear	Scrubbed	Coupon Type
	Before	After	Yes/No	
F1006A	0.03	25.48	No	DU
	Before	After		
F1014A	0.23	1.45	No	DU-Nb
F1015A	0.20	12.04	No	DU-Nb
F1016A	0.79	0.58	No	DU-Nb
	Before	After		
F992A	0.00	6.66	Yes	DU
F998A	0.01	32.09	Yes	DU
F1002A	0.01	10.69	Yes	DU
F1004A	0.02	13.38	Yes	DU
F1005A	0.00	7.71	Yes	DU
	Before	After		
F1007A	0.02	1.97	Yes	DU-Nb
F1008A	0.02	3.23	Yes	DU-Nb
F1009A	0.00	4.7	Yes	DU-Nb
F1010A	0.02	11.65	Yes	DU-Nb

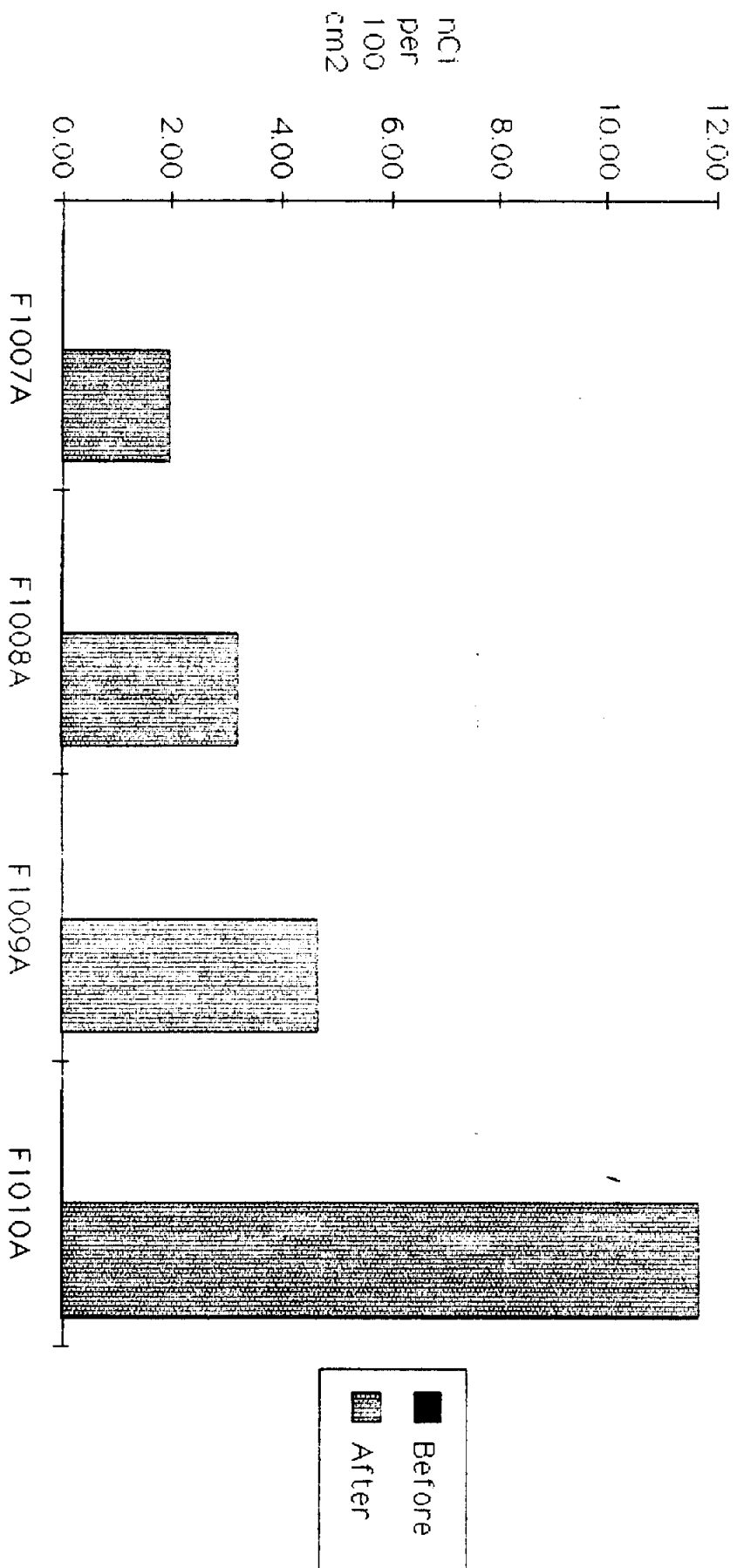
DU Unscrubbed Coupon



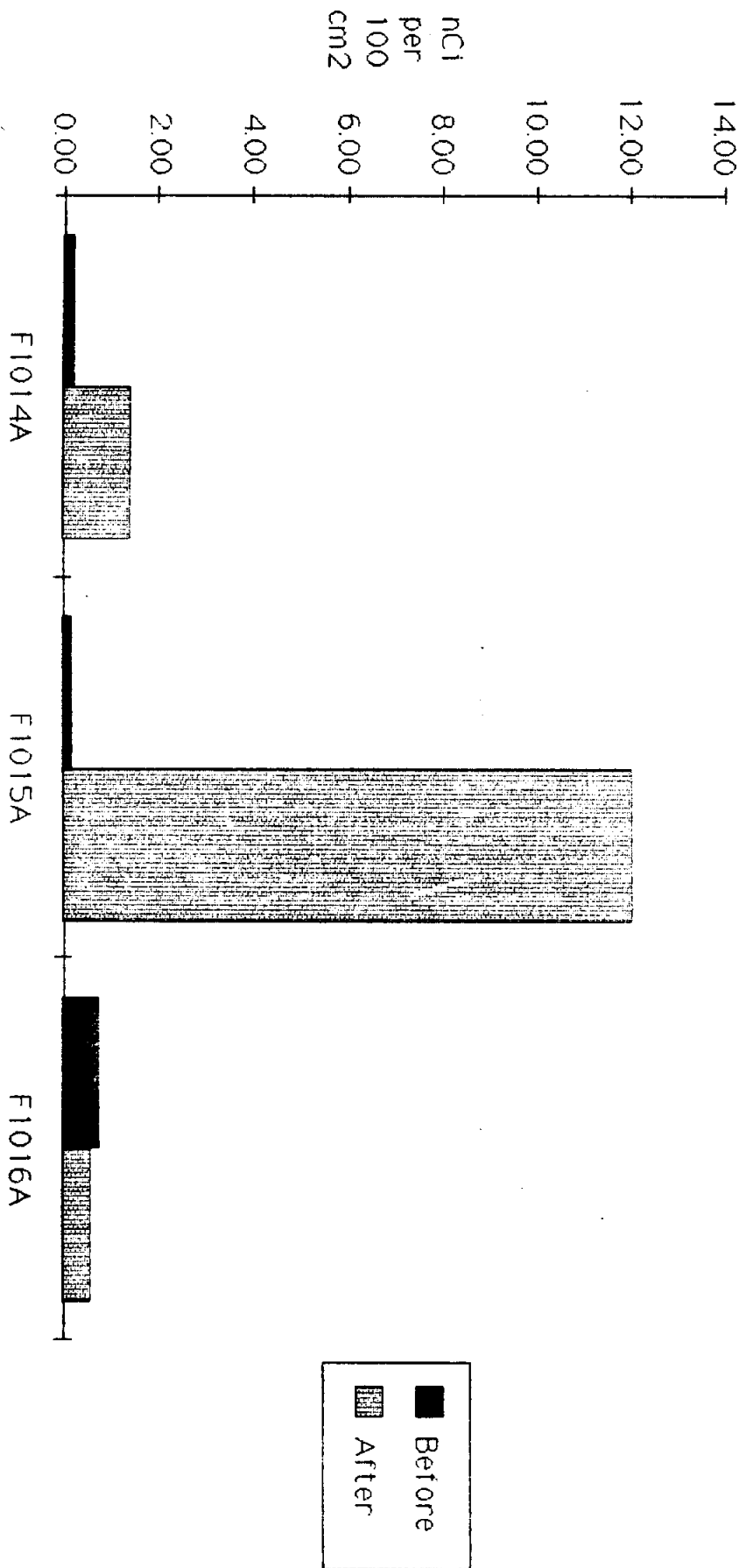
DU Scrubbed Coupons



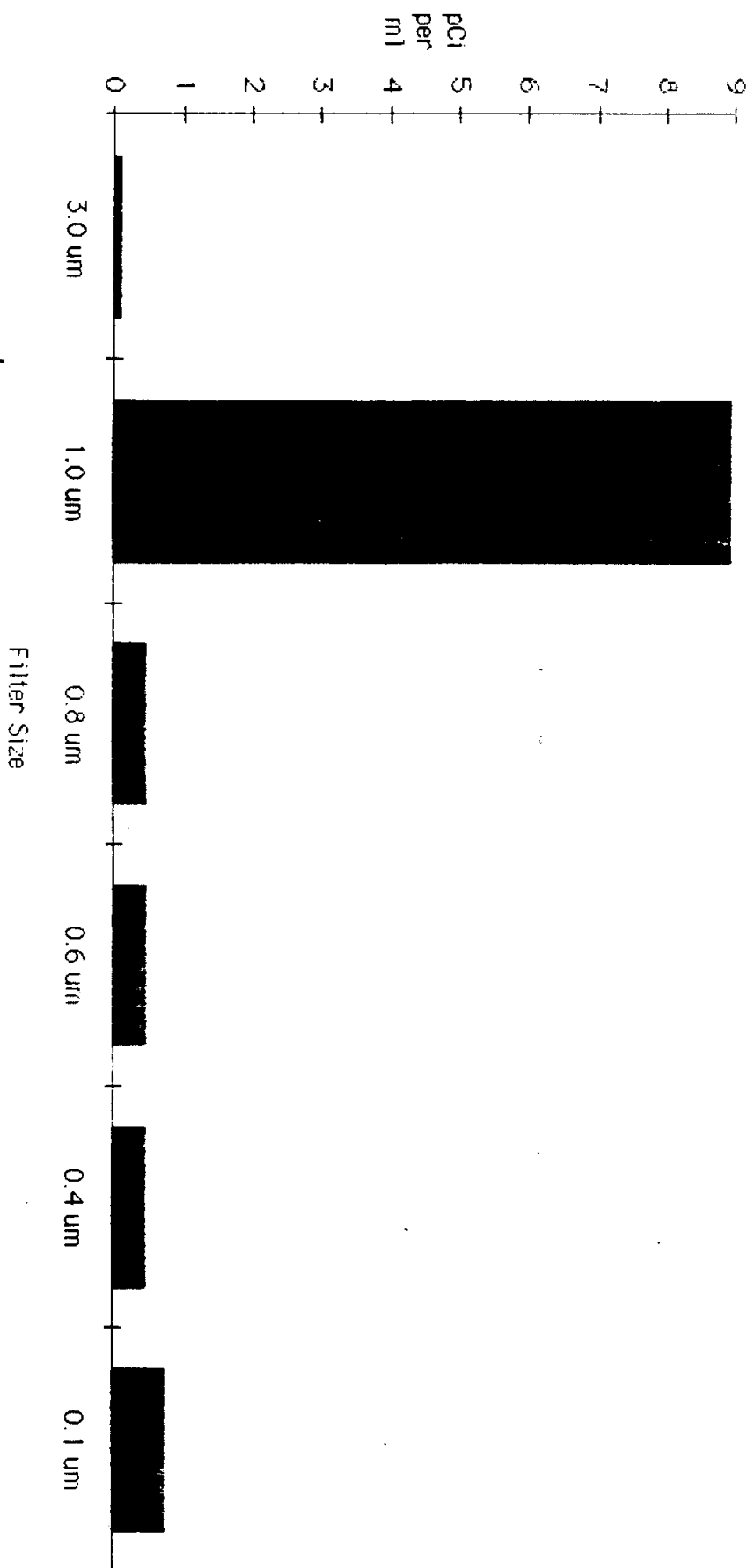
DU-Nb Scrubbed Coupons



DU-Nb Unscrubbed Coupon



Second Settling Test
Particle Size Analysis at Conclusion of Test
3/22/88





March 23, 1988
DRAFT

SUBJECT: Corrosion Test in Dry Nitrogen Atmosphere - 2nd Test

The purpose of this test was to determine if uranium corrodes in a dry nitrogen atmosphere at normal room temperatures. Since uranium corrosion in air is readily identifiable by a rapid color change, it was assumed that contamination smears would not be required to determine if the uranium had corroded.

Test Preparation 3/14

The coupons were scrubbed with Scotchbrite and alcohol and were immediately placed in a plastic bag. The bag was almost completely sealed; a slight opening was left in the top of the bag to permit positive flow of N₂ gas out of the bag. The N₂ gas flow into the bag was set at >>0.5 lpm for approximately fourteen minutes to purge all O₂ from the bag. The N₂ flow was then set to about 0.5 lpm for the duration of the test.

First Observation 3/18

The coupons were inspected through the bag; they were not removed from the N₂ atmosphere. The coupons were bronze in color rather than silver.

Second Observation 3/23

The coupons were still bronze in appearance. Smears were taken on both sides of these coupons.

Conclusions

Three DU coupons were scrubbed and were left in air from 3/11/88 until 3/23/88. These coupons were compared to those kept in the N₂ purge during the test. These three coupons were very black compared to those left in the N₂ purge bag. Based on color, it appears that the coupons left in air were more oxidized.

Smears were taken on each side of the two coupons in the N2 bag and on each side of the coupons left in air. No smears were taken at the beginning of the test since the test was intended to be colorimetric in nature. The results of the actual smears are listed below. Typical contamination level values for scrubbed coupons are given as beginning level values.

Coupon Number	Beginning Level	Ending Level	Air/N2	Type
F999A	0.02	<0.08	N2	DU
F999B	0.02	<0.12	N2	DU
F1011A	0.11	0.10	N2	DU-Nb
F1011B	0.11	0.12	N2	DU-Nb
F1000A	0.02	<0.11	Air	DU
F1000B	0.02	<0.12	Air	DU
F1001A	0.02	0.10	Air	DU
F1001B	0.02	0.10	Air	DU
F1003A	0.02	0.10	Air	DU
F1003B	0.02	0.11	Air	DU
